Science Committee Report

Dr. Bradley M. Peterson
Chair, Science Committee

Science Committee Members

Brad Peterson, Chair, The Ohio State University and Space Telescope Science Institute
Carle Pieters, Vice Chair, Brown University

Steve Running, University of Montana, Chair of Earth Science Subcte
Scott Gaudi, The Ohio State University, Chair of Astrophysics Subcte
Jill Dahlburg, Naval Research Laboratory, Chair of Heliophysics Subcte
Robert Lindberg, University of Virginia, Chair of Planetary Protection Subcte

Doug Duncan, University of Colorado
Mark Robinson, Arizona State University
James Green, University of Colorado at Boulder
Susan Avery, Woods Hole Oceanographic Institute
Tamara Jernigan, Lawrence Livermore National Laboratory
Walter Secada, University of Miami

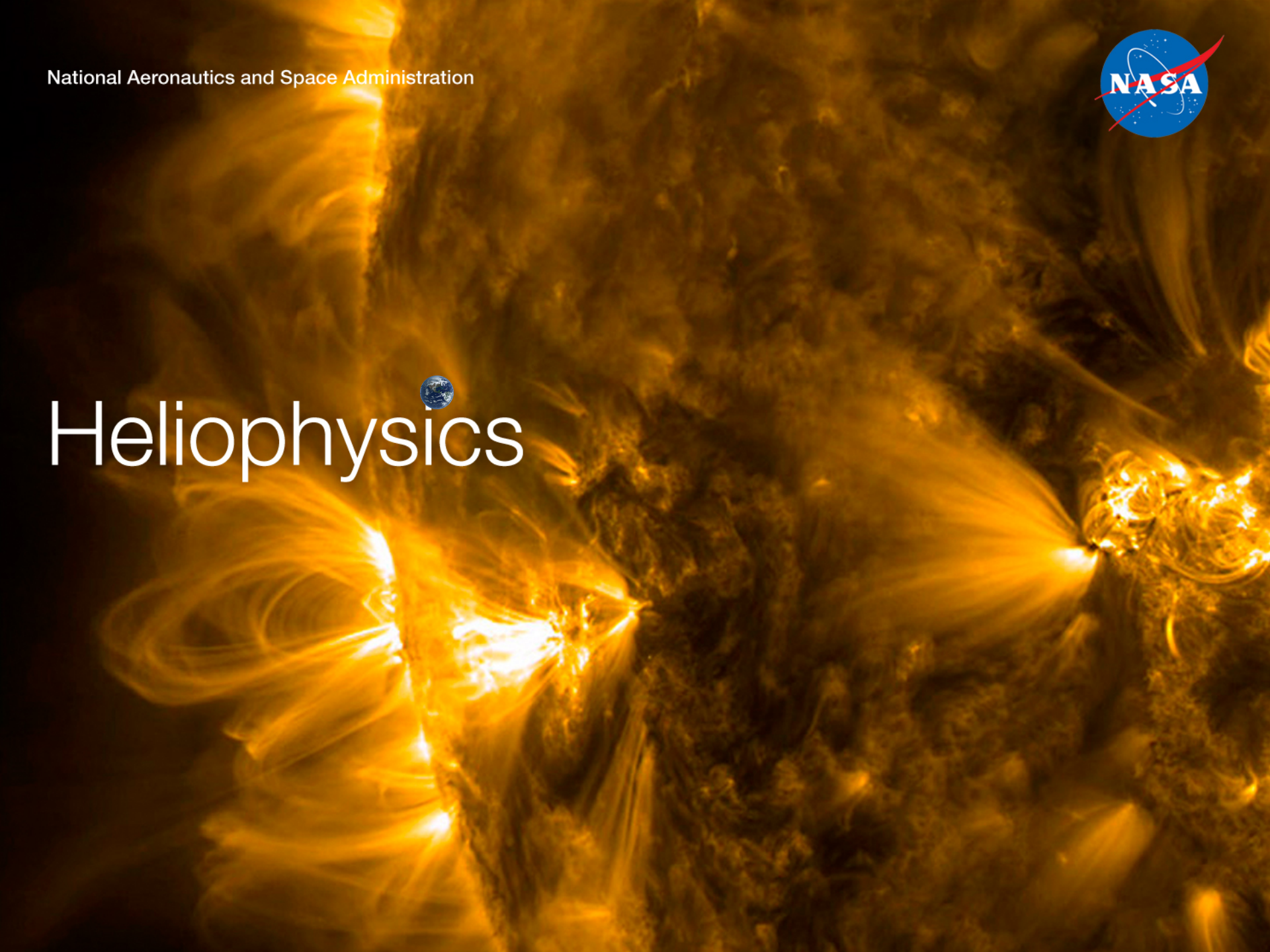
David Spergel, Chair of Space Studies Board (*ex officio* member)

3 appointments in process: Chair of Planetary Science Subcte, Heliophysics At-Large Seat, Astrophysics At-Large Seat

Outline

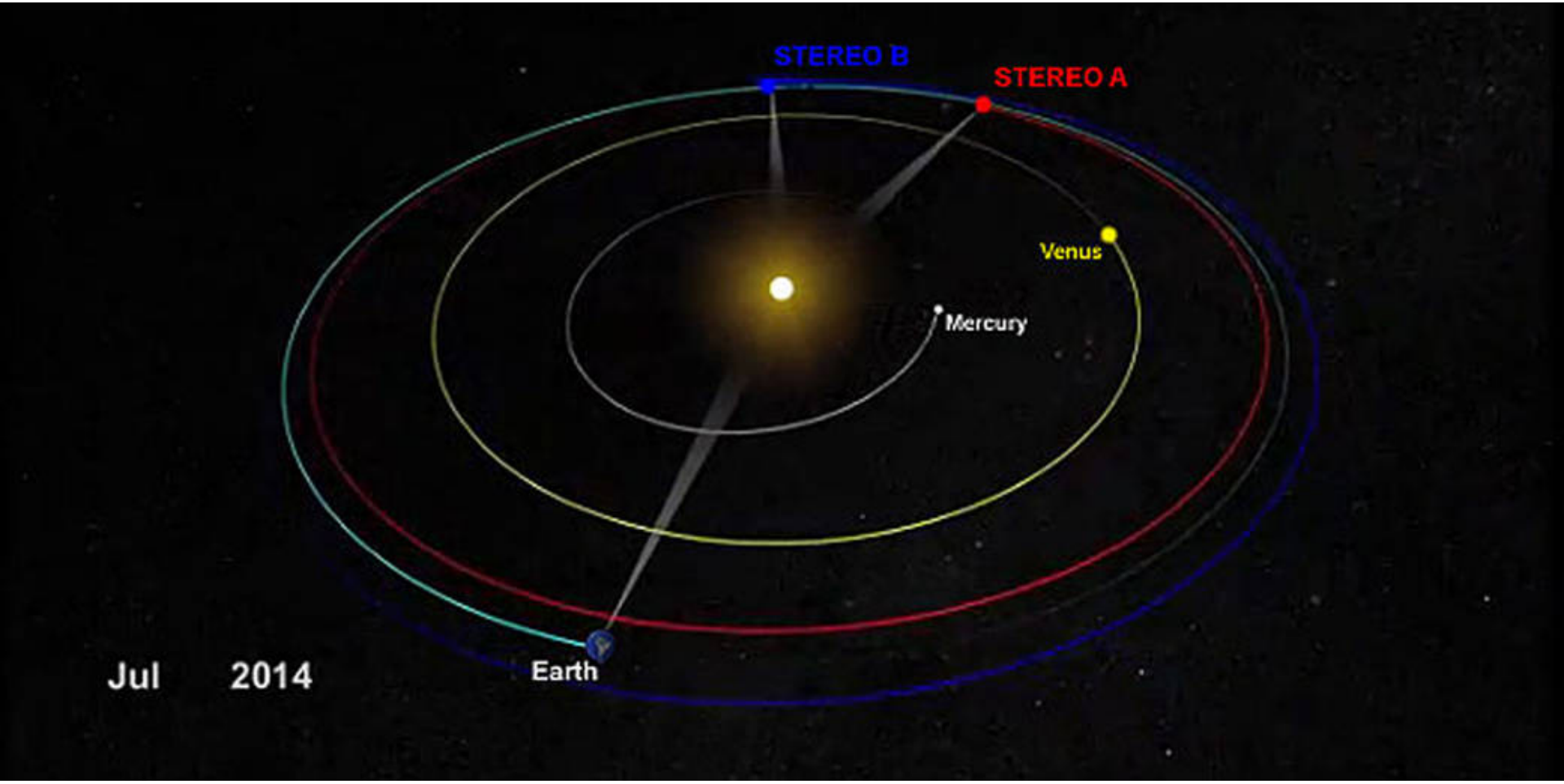
- **Science Results**
- Programmatic Status
- Findings

National Aeronautics and Space Administration



Heliophysics

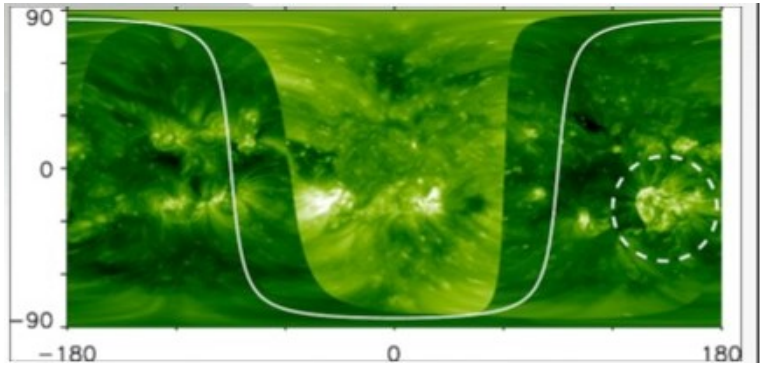
STEREO A & B allow a 360° view of the Sun



360 Sun: Highlighting 10 Years of Heliophysics STEREO Mission Data and Observations

Before the Heliophysics STEREO mission was launched ten years ago,we were only able to take observations of the sun and solar wind from Earth's perspective. STEREO's revolutionary mission design has afforded us different views of the sun - simultaneously. STEREO's two nearly identicalspace-based observatories - one ahead of Earthin its orbit, the other trailing behind -have provided the first-ever stereoscopic measurements of the sun.STEREO waslaunched to improve our understanding of the solar corona, the origins and propagat on of Coronal Mass Ejections (CMEs) and the solar wind,and to better understand the trajectory of Solar Eneroetjc partjclesISEPs\ traveling from the suninto the interplanetary magnetic field. Allof these events and phenomena drive the space weather conditions impacting Earth, other objects and other planetary systems in our solar system. Since STEREO has been in orbit it has contributed a wealth of data including multi-point observations only STEREO could provide of one of the fastest CMEs on record and the most intense SEP event in decades. On July 23'•, 2012, the CME originated on the far side of the sun, and, without STEREO,researchers might not have known the event occurred at all.

STEREO has made it possible to track CMEs,and the solar wind, from the sun to Earth whie at the same time measuring them in-situ (or locally), enhancing our understanding of CME and solar wind structures as they travel through space. STEREO data has been combined with SDO data to determine CME speeds and trajectories more accurately, resulting in a 50% improvement in CME prediction times. STEREO data analyzed alongside ACE data on the July 2012 CME show distinct differenc.es in space weather impacts at differentlocations in the solar system, giving scientists deeper insight into the physics of space weather andimpacts on thelocal environment.



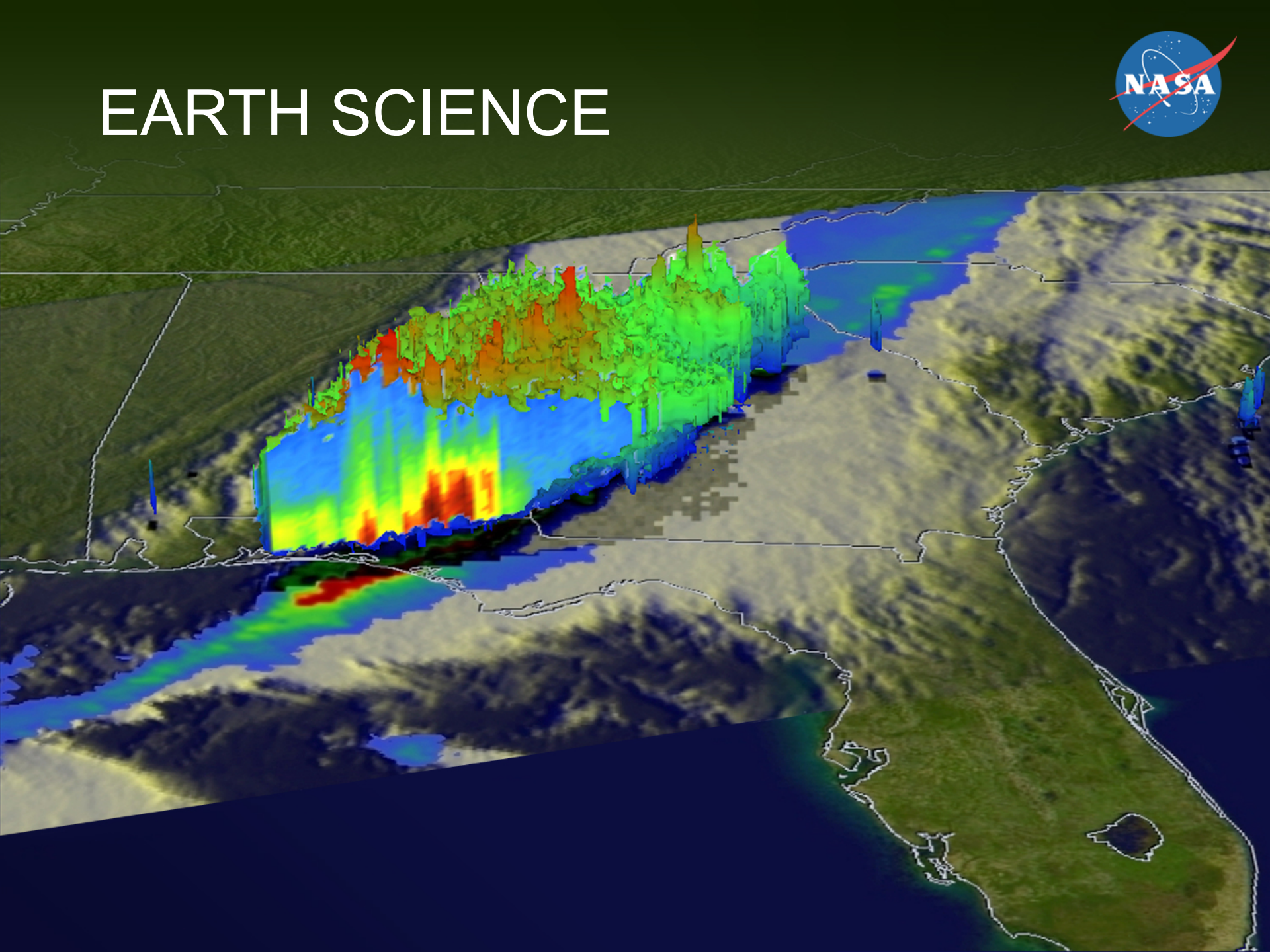
This is a Carrington map which provides a Mercator projection-like view of the sun using STEREO A, STEREO 8 and SDO data on 23 July 2012. The dashed circle indicates the area in which the CME occurred. The while, u-shaped line distinguishes the area visible from Earth and uses the SDO data. Without STEREO we wouldn 't have been able to observe this historical CME or any of the areas outside the white, u-shaped line. The degrees on each axis represent heliolatitude verically and heliolongilude horizontally.

Credit: NASA STEREOISDO

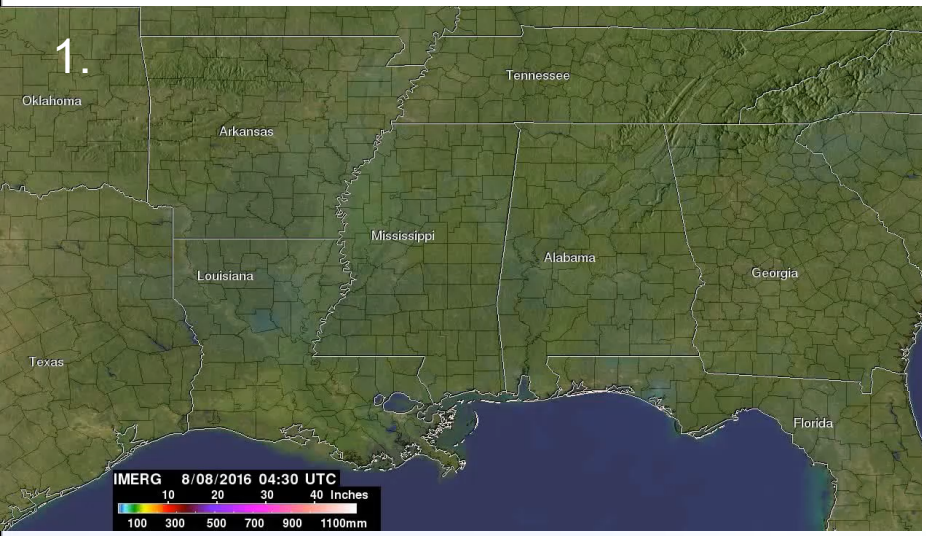
STEREO data has been used to analyze and model the distribution of SEPs, a significant space weather hazard,from their origins in solar flares and CMEs into the interplanetary medium. CME shocks accelerate SEPs and STEREO data has been used to modelthis as well. Mapping multipoint magnetic polarity and comparing STEREO data to globalsolar wind modelslike ENLIL has also advanced space weather science and understand ing.

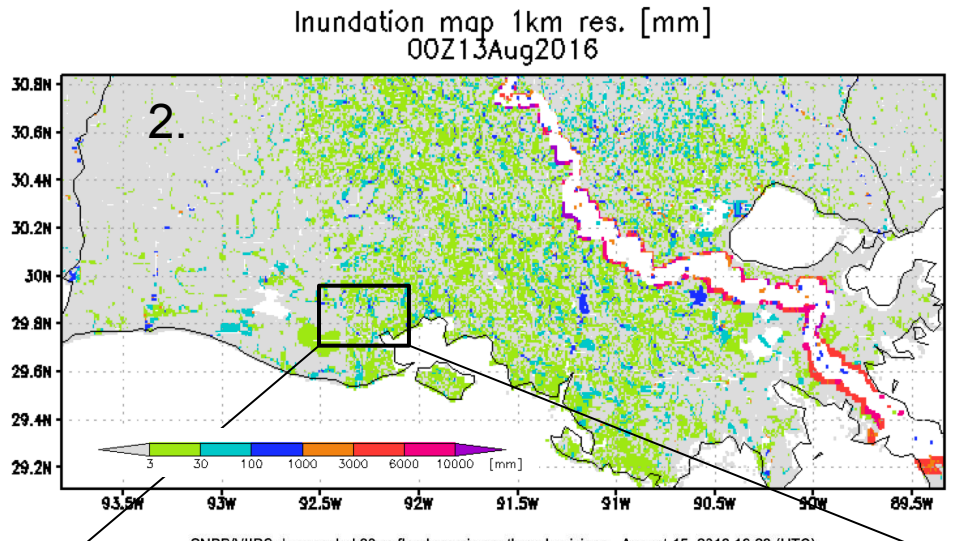
The two points of observation STEREO provided madeit possible to model the magnetic fields of structures in the solar corona - including active regions, jets and erupting prominences - for the first timein 30. This capability of the STEREO mission also brought us the first-ever simultaneous view of the entire star at once. The STEREO spacecraft are *a* part of the larger Heliophysics Systems Observatory /HSO\, which includes missions like SDO, fil2jjQ and ACE. STEREO data and observations have added new and unique perspectives to the HSO.STEREO's 10'" anniversary in orbit was celebrated on October 25, 2016 at the NationalAir and Space Museum with a public panelhighlighting the mission's contr butions to the science of space weather and space weather hazards.

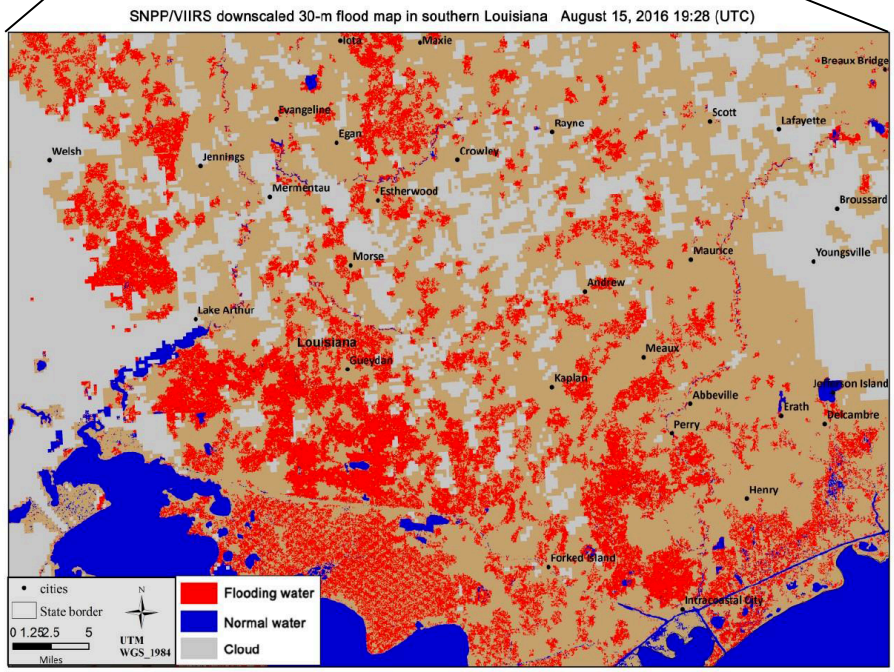
EARTH SCIENCE



NASA Observes Historic Rainfall and Maps Flooding in Louisiana





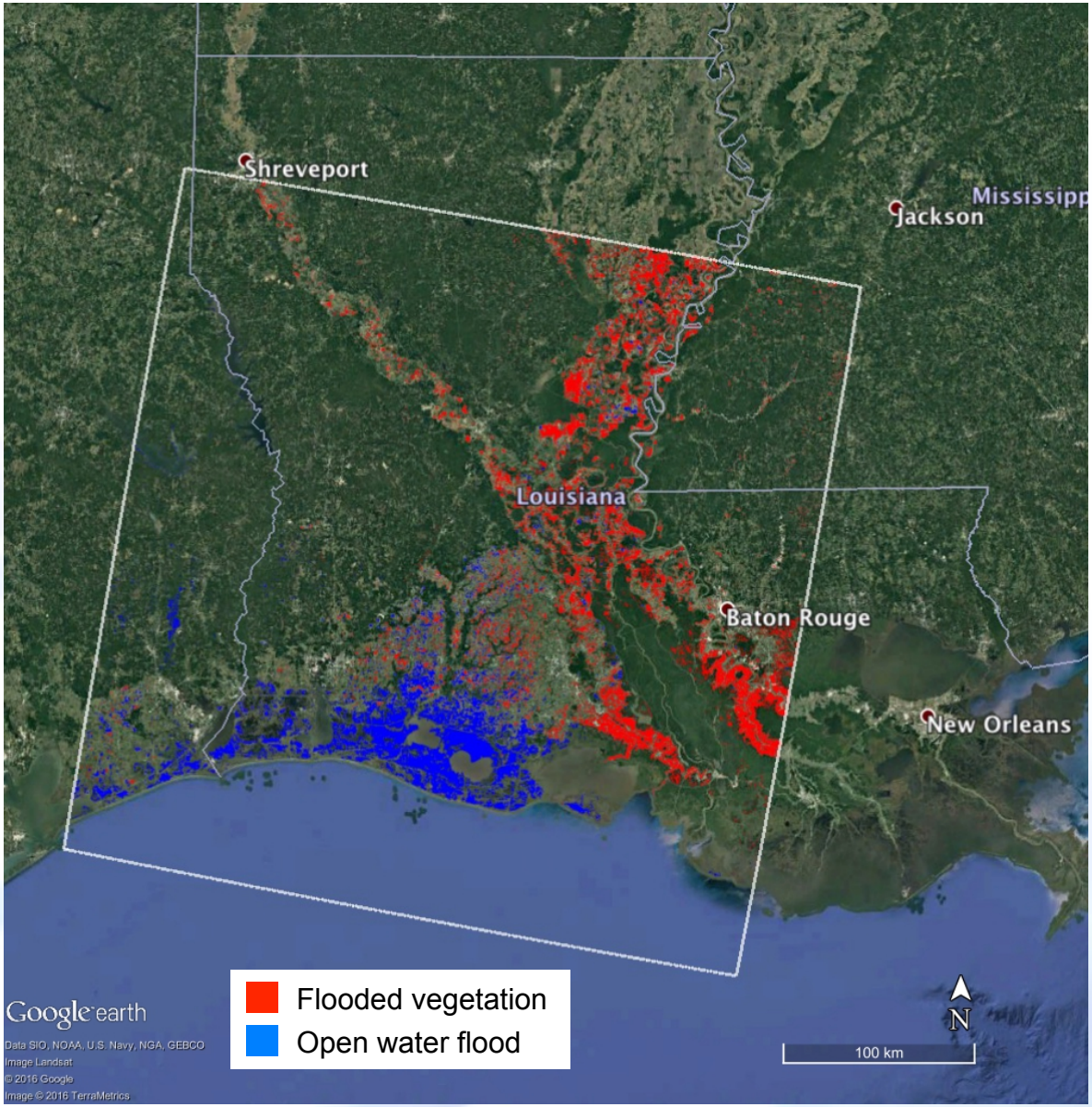


Examples of Daily NASA Products Provided to FEMA and state emergency managers for response to the historic rainfall and flooding in Louisiana.

Top L-R 1. NASA's Integrated Multi-satellitE Retrievals for GPM (IMERG) data show the historic amount of rain that fell from August 8-15 in the Gulf Coast (Pierce/SSAI-NASA). 2. Global Flood Monitoring System Inundation Map showing inundation around the Mississippi River (Adler/U of Maryland); **Bottom R**. VIIRS downscaled 30-m flood map in southern Louisiana from August 15th showing the extent of the flood water (Sun/George Mason University).

Not Shown: VIIRS Day-Night Band for power outage detection.

NASA Coordinates Space-Air-Ground Observations for Historic Flooding in Louisiana



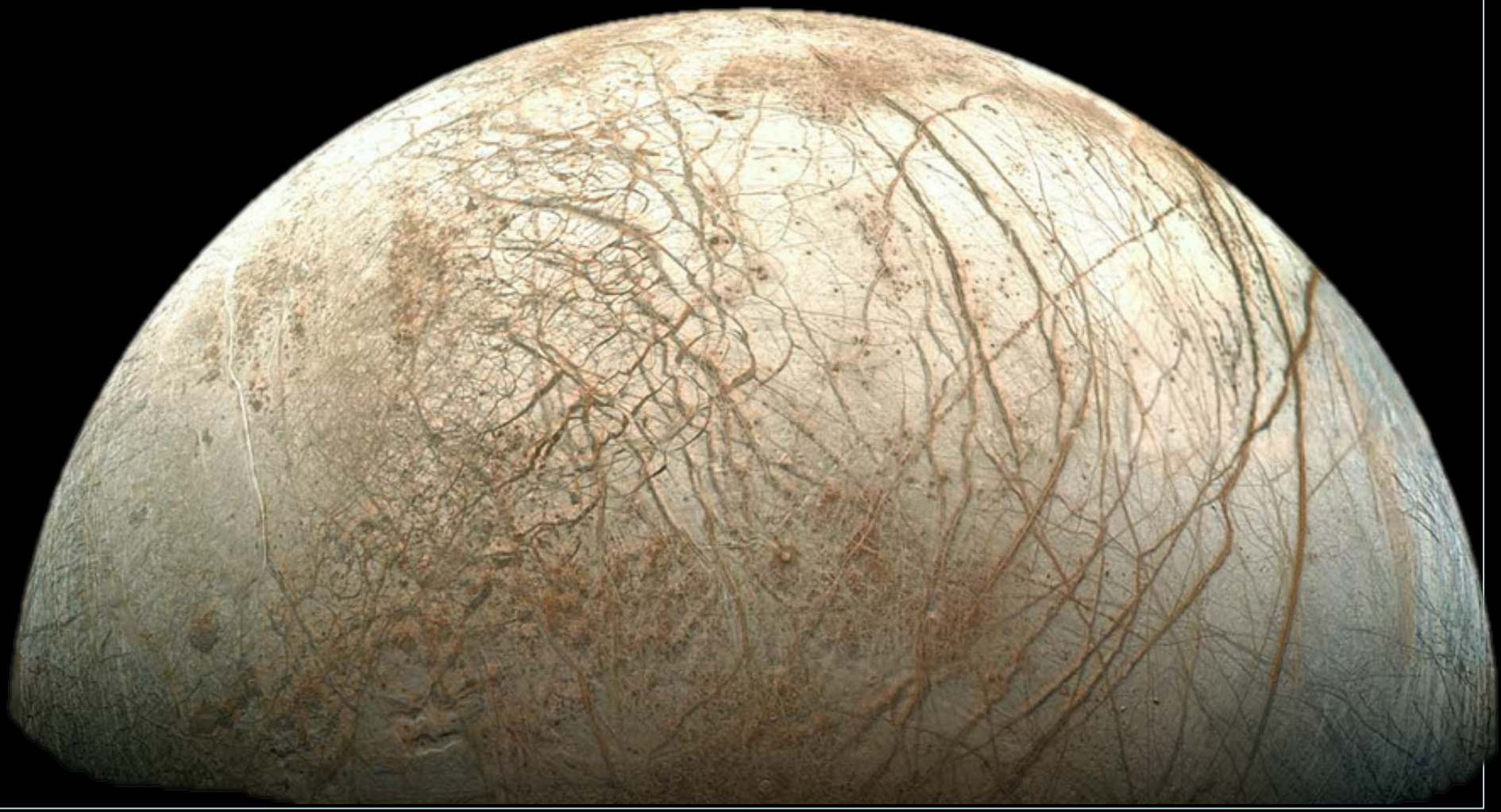
Example of Flood Proxy Map, Constrained by Spaceborne, Airborne, and Ground Observations

Provided to FEMA and state emergency managers for response to the historic rainfall and flooding in Louisiana.

Space: JAXA's ALOS-2 SAR data (through International Charter)
Air: NOAA Aerial Photos
Ground: USGS Water Edge Survey

The Advanced Rapid Imaging and Analysis (ARIA) team at JPL and Caltech produced detailed comprehensive cloud-free flood extent maps covering most of Louisiana (350 km x 350 km footprint, at 50 m pixel spacing), derived from JAXA's ALOS-2 SAR data acquired on August 18th, calibrated with USGS water edge locations and NOAA aerial photos.

Planetary Science

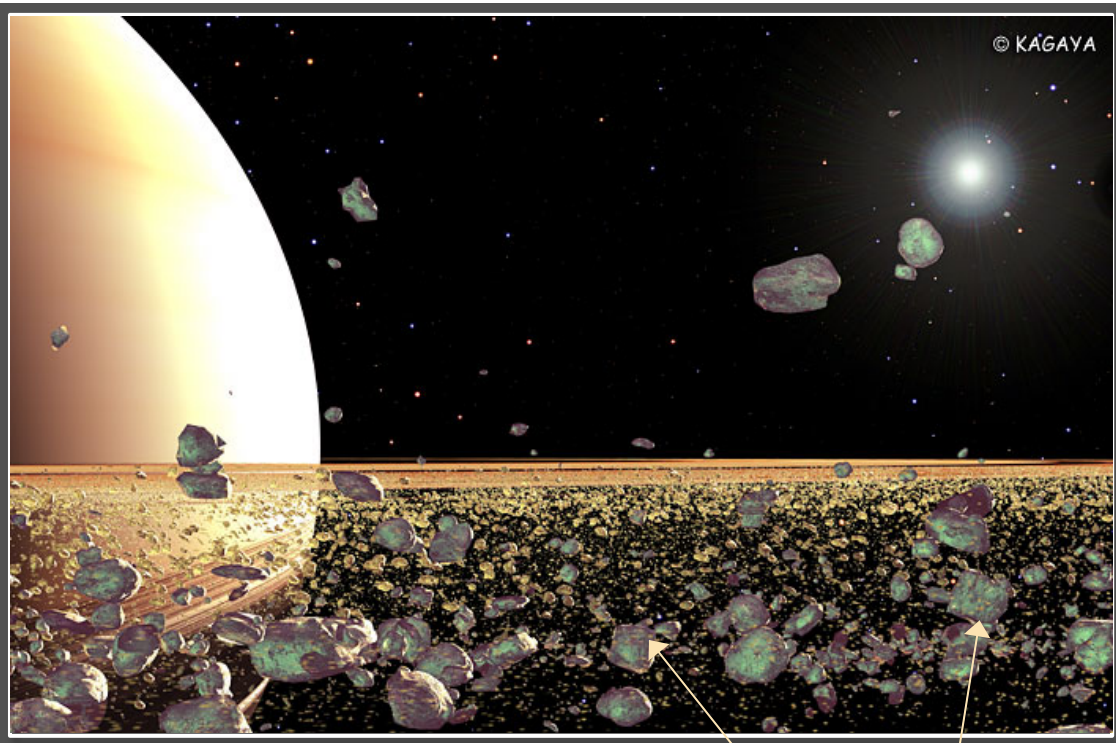


A Surprisingly Young Region in Saturn's Rings

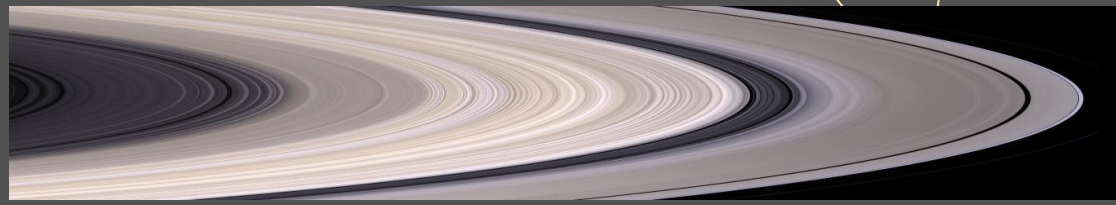
Chunks of solid ice in the middle of Saturn's A ring suggest an unexpectedly young ring region.

- Recent results from Cassini's infrared spectrometer found that particles in one section of Saturn's rings are much denser than the normally fluffy particles elsewhere.
- After equinox, when the sun shines edge-on to Saturn's rings, one section of the A ring did not cool down as much as expected, providing a unique window into the interior of the ring particles.
- Perhaps a tiny moon broke apart only 100 million years ago and its solid, icy fragments are slowly spreading through the rings.

Saturn's rings may therefore be a mix of young and old material, providing clues to their formation and evolution.

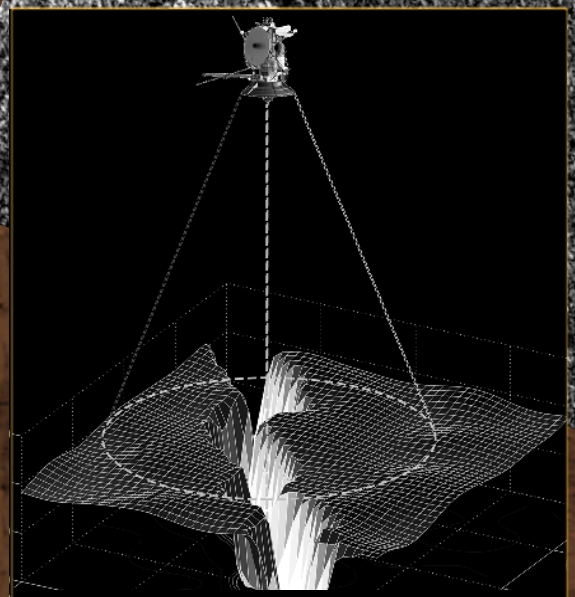


Above: Model of Saturn's rings showing both small and large particles.
Below: Estimated location in A ring of denser particles.



"Incomplete cooling down of Saturn's A ring at solar equinox: Implication for seasonal thermal inertia and internal structure of ring particles," Morishima, et al., Icarus, 279, 2-19, 2016. doi:j.icarus.2015.06.025

Rivers of Hydrocarbons Flow Through Titan's Narrow Canyons



In the "Vid Flumina" river channel network, radar found nearly vertical canyons up to one-third mile deep and less than a half-mile wide. The radar echo from the canyon bottom showed the presence of liquid.

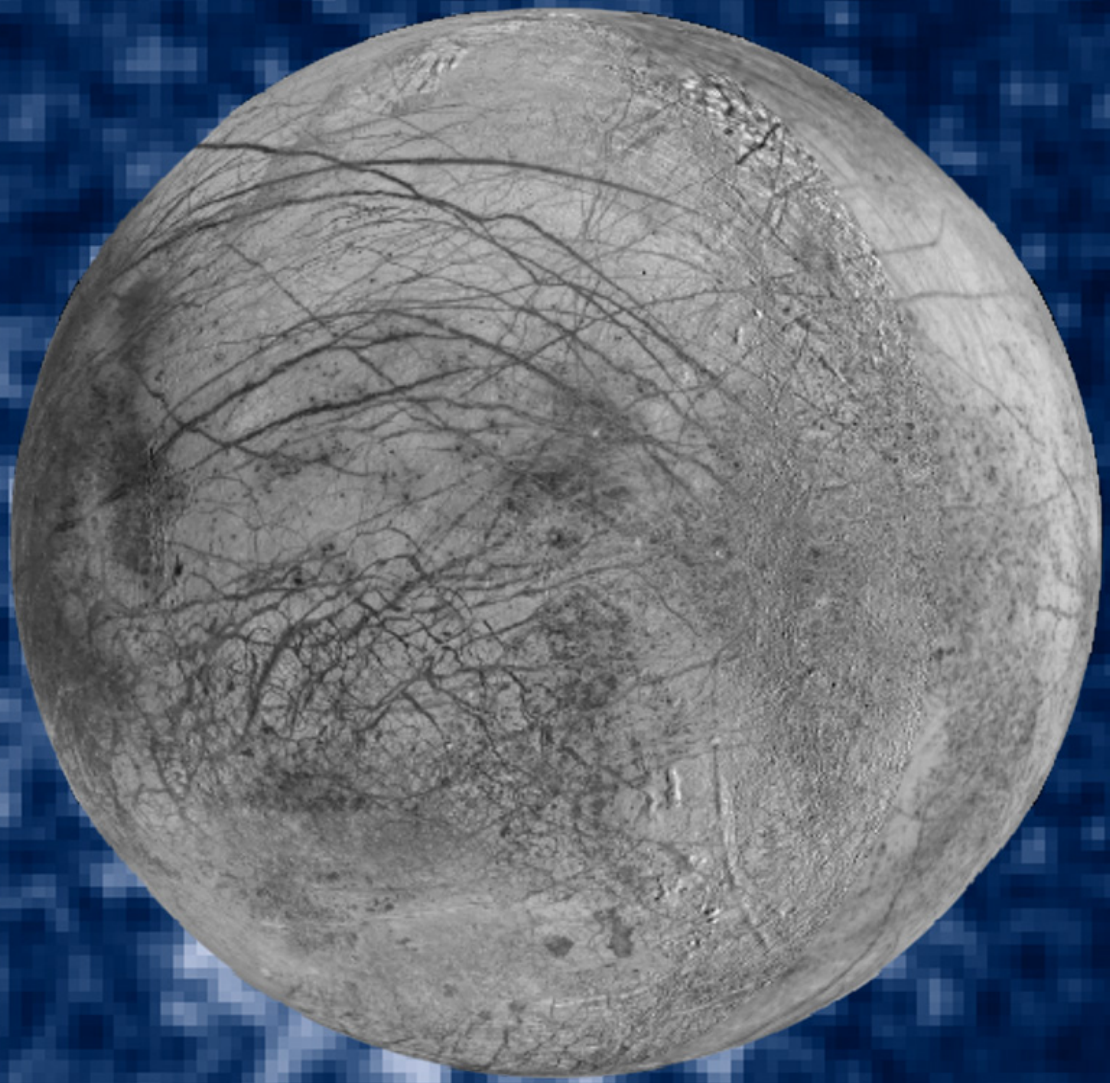
Cassini radar and altimeter echoes have revealed surprisingly deep (up to 1000 feet), steep canyons that are home to rivers of hydrocarbons on Saturn's moon Titan. These canyons appear to be connected to Titan's northern lake, Ligeia Mare.

The Titan canyons may have formed either when the land rose tectonically or the sea level temporarily dropped. Both mechanisms helped to carve the river canyons of the American Southwest. On Titan, however, the liquid is methane and ethane, not water, and the surface is rock-hard mix of water ice and solid hydrocarbons.

Upstream tributaries were found to be much higher than Ligeia's sea level. This difference would cause flow that could erode Titan's deep canyons in the way the Colorado River carved the Grand Canyon. The liquid at the river's mouth and main trunk, however, was level with the sea. This may be a sign of backflooding, producing a drowned river valley similar to the Georges River in Australia.

Poggiali, V., et al. (2016), GRL, doi:10.1002/2016GL069679

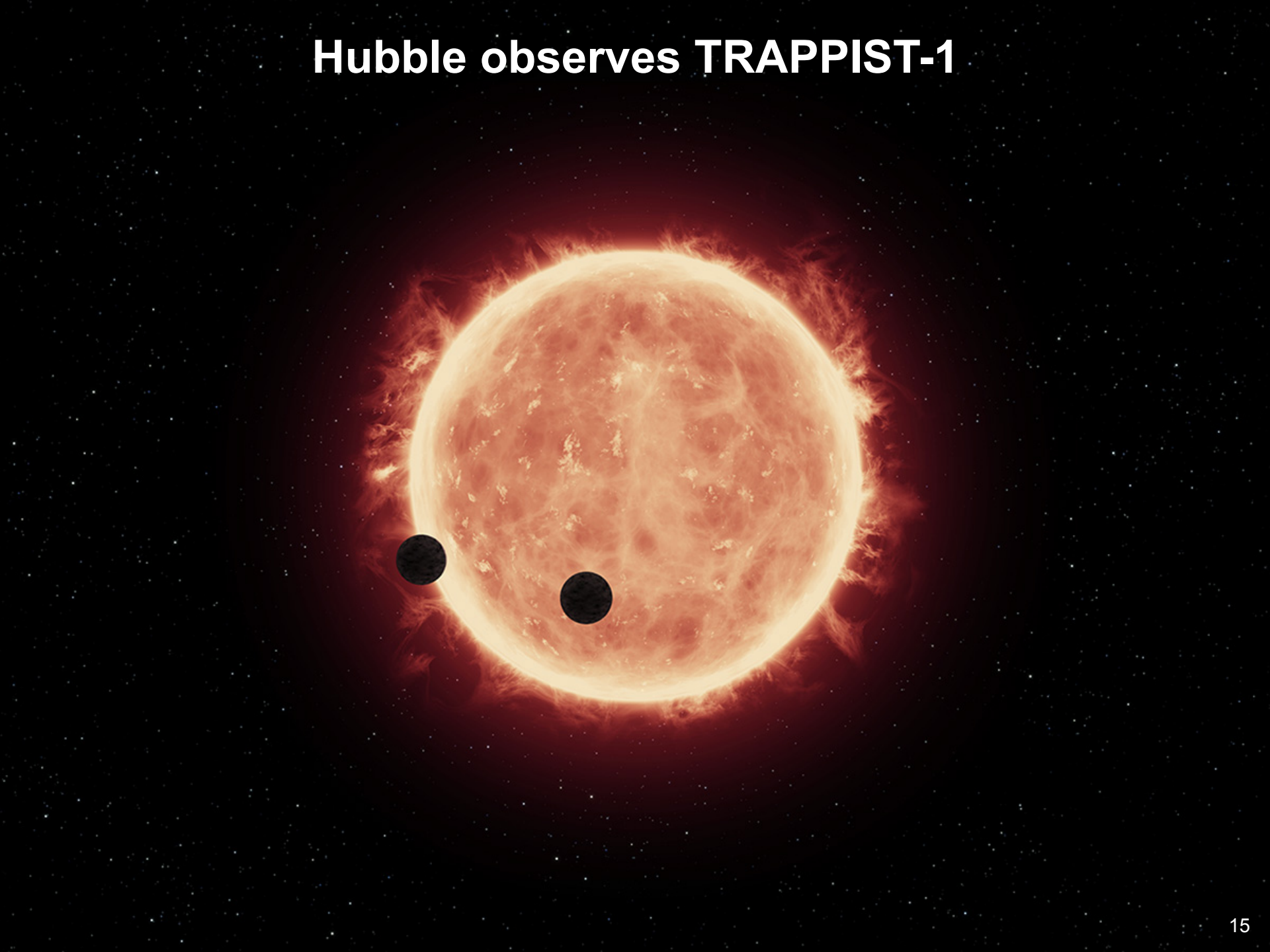
Hubble observes possible water plumes from Europa



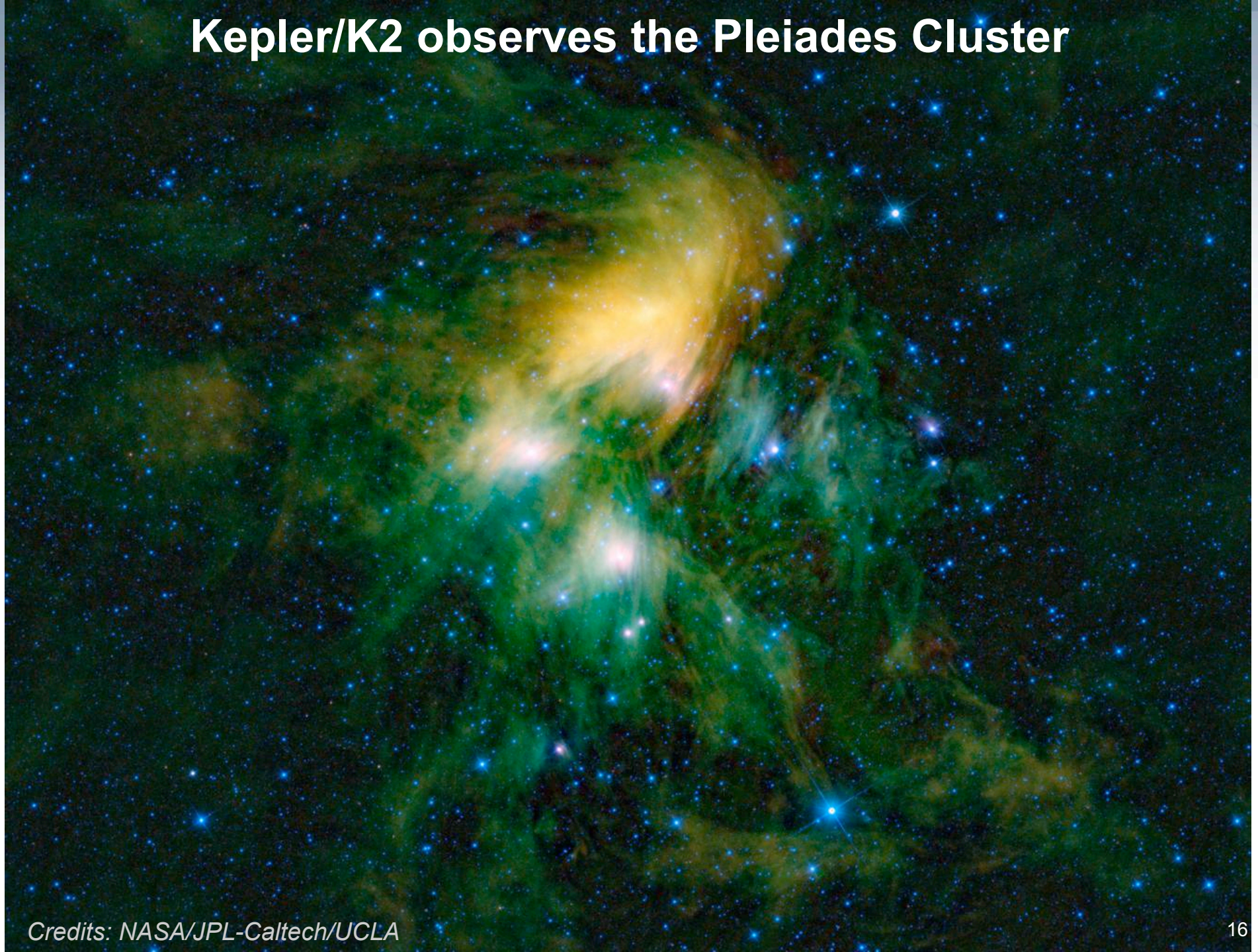
National Aeronautics and Space Administration

Astrophysics

Hubble observes TRAPPIST-1

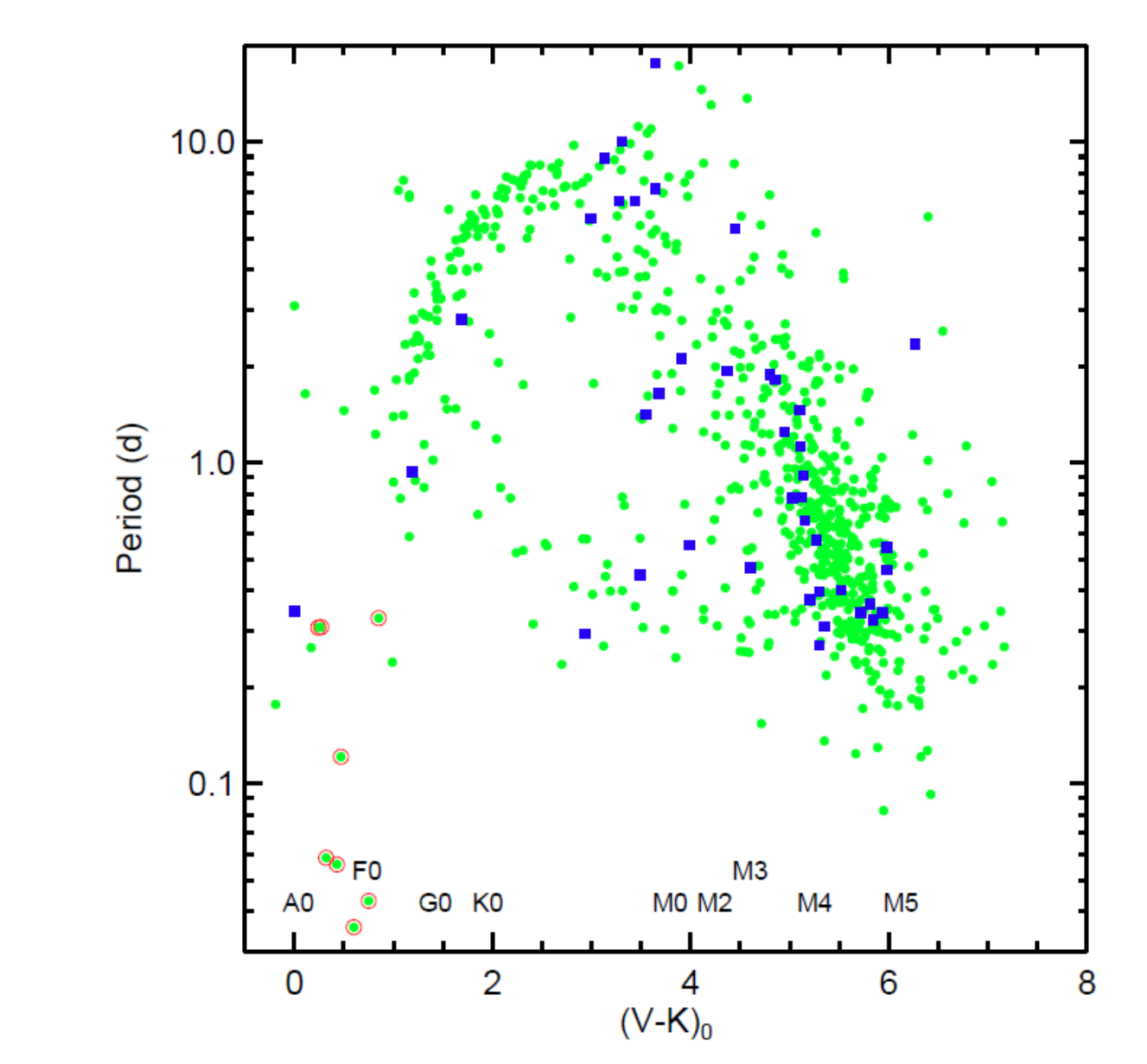


Kepler/K2 observes the Pleiades Cluster



Credits: NASA/JPL-Caltech/UCLA

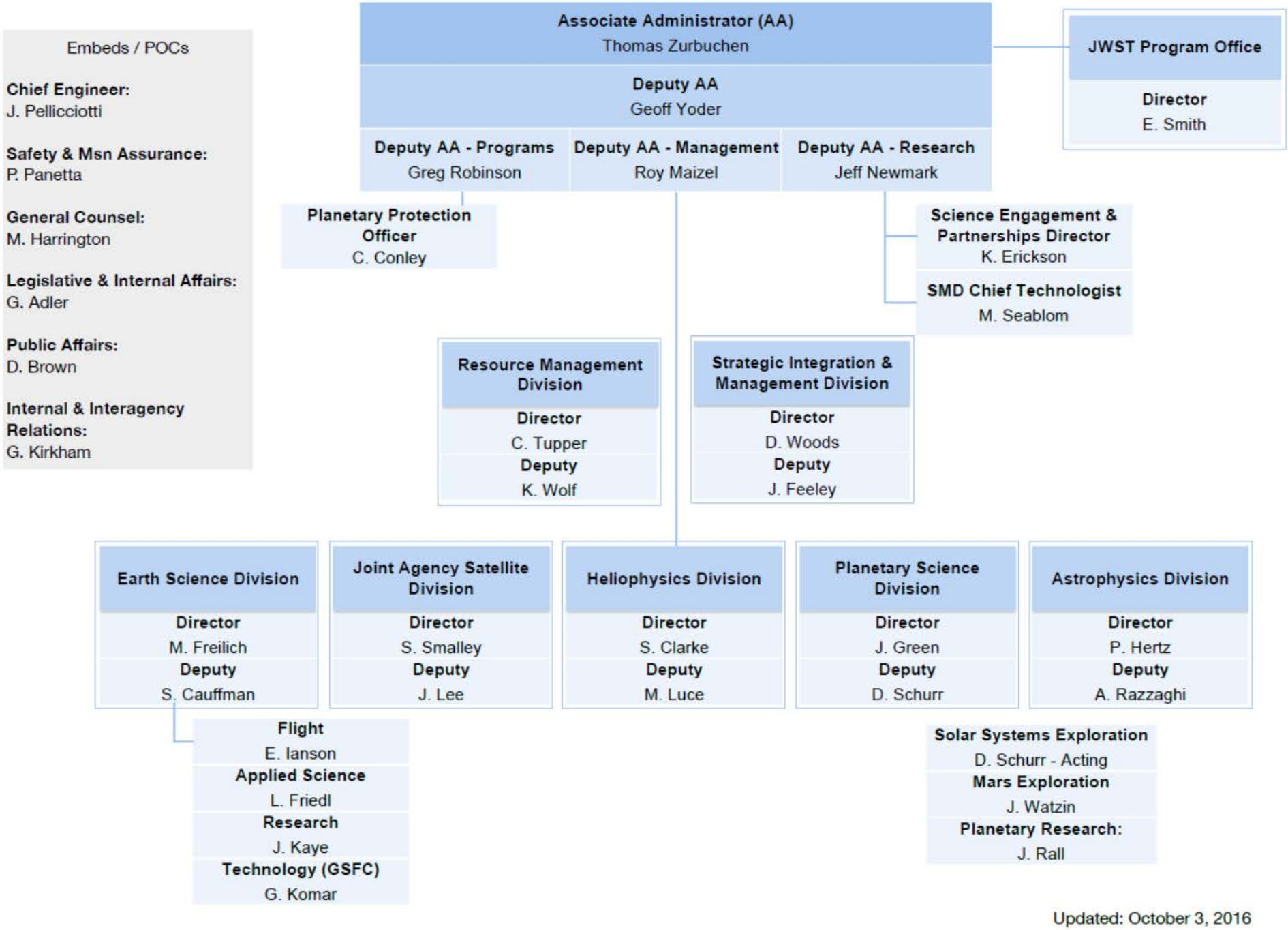
Kepler/K2 observes the Pleiades Cluster



Credits: NASA/JPL-Caltech/UCLA

Outline

- Science Results
- **Programmatic Status**
  - Science Mission Directorate
  - Heliophysics
  - Earth Science
  - Planetary Science
  - Astrophysics
  - Other Reports
- Findings


Embeds / POCs
Chief Engineer:
J. Pellicciotti
Safety & Msn Assurance:
P. Panetta
General Counsel:
M. Harrington
Legislative & Internal Affairs:
G. Adler
Public Affairs:
D. Brown
Internal & Interagency Relations:
G. Kirkham
Associate Administrator (AA)
Thomas Zurbuchen
Deputy AA
Geoff Yoder
Deputy AA - Programs
Greg Robinson
Deputy AA - Management
Roy Maizel
Deputy AA - Research
Jeff Newmark
JWST Program Office
Director
E. Smith
Planetary Protection Officer
C. Conley
Science Engagement & Partnerships Director
K. Erickson
SMD Chief Technologist
M. Seablom
Resource Management Division
Director
C. Tupper
Deputy
K. Wolf
Strategic Integration & Management Division
Director
D. Woods
Deputy
J. Feeley
Earth Science Division
Director
M. Freilich
Deputy
S. Cauffman
Joint Agency Satellite Division
Director
S. Smalley
Deputy
J. Lee
Heliophysics Division
Director
S. Clarke
Deputy
M. Luce
Planetary Science Division
Director
J. Green
Deputy
D. Schurr
Astrophysics Division
Director
P. Hertz
Deputy
A. Razzaghi
Flight
E. Ianson
Applied Science
L. Friedl
Research
J. Kaye
Technology (GSFC)
G. Komar
Solar Systems Exploration
D. Schurr - Acting
Mars Exploration
J. Watzin
Planetary Research:
J. Rall
Updated: October 3, 2016

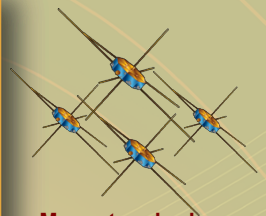
SMD AA Dr. Thomas Zurbuchen conversation with the NAC Science Committee

Thomas Zurbuchen Named Head of NASA Science Mission Directorate

NASA Administrator Charles Bolden has named Thomas Zurbuchen as the new associate administrator for the Science Mission Directorate at the agency's headquarters in Washington, effective Monday, Oct. 3.

Heliophysics Program 2015-2024

Solar Terrestrial Probes



Magnetospheric Multiscale (MMS)
March 2015

Interstellar Mapping Probe (IMAP) (STP #5)
2023*

Heliophysics MO
2023*

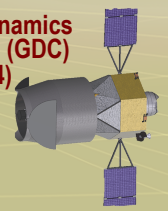
Living With a Star

Space Environment Testbeds (SET)
NET September 2017

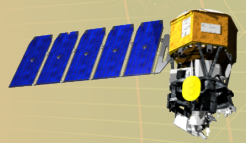
Solar Probe Plus
July 2018

Solar Orbiter Collaboration (with ESA)
October 2018

Geospace Dynamics Constellation (GDC) (LWS #4)
2024*

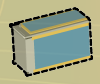


Explorers



Ionospheric Connection Explorer (ICON)
October 2017

Global-scale Observations of the Limb and Disk (GOLD)
April 2018

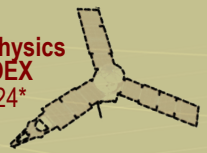


Heliophysics MO
2020*

Heliophysics SMEX
2022*

Heliophysics MO
2022*

Heliophysics MIDEX
2024*



Heliophysics MO
2024*

Research Program

Solar/Heliospheric: November 2016
Solar/Heliospheric – December 2016
Solar/Heliospheric – December (tbd) 2016

Ongoing

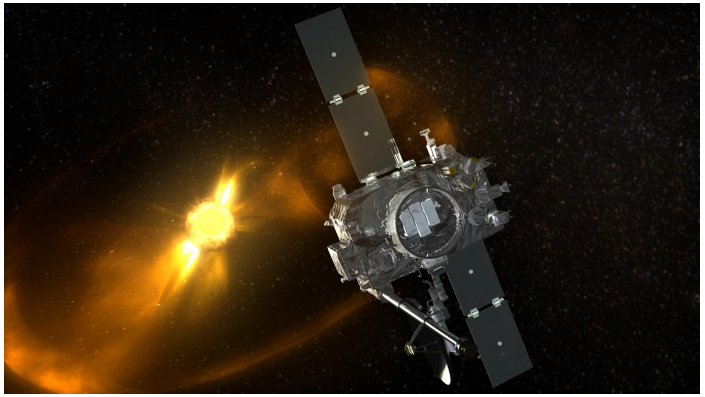
Heliophysics Missions
Astrophysics Missions
Planetary Missions

2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

*Notional

STEREO B Recovery Attempt Status

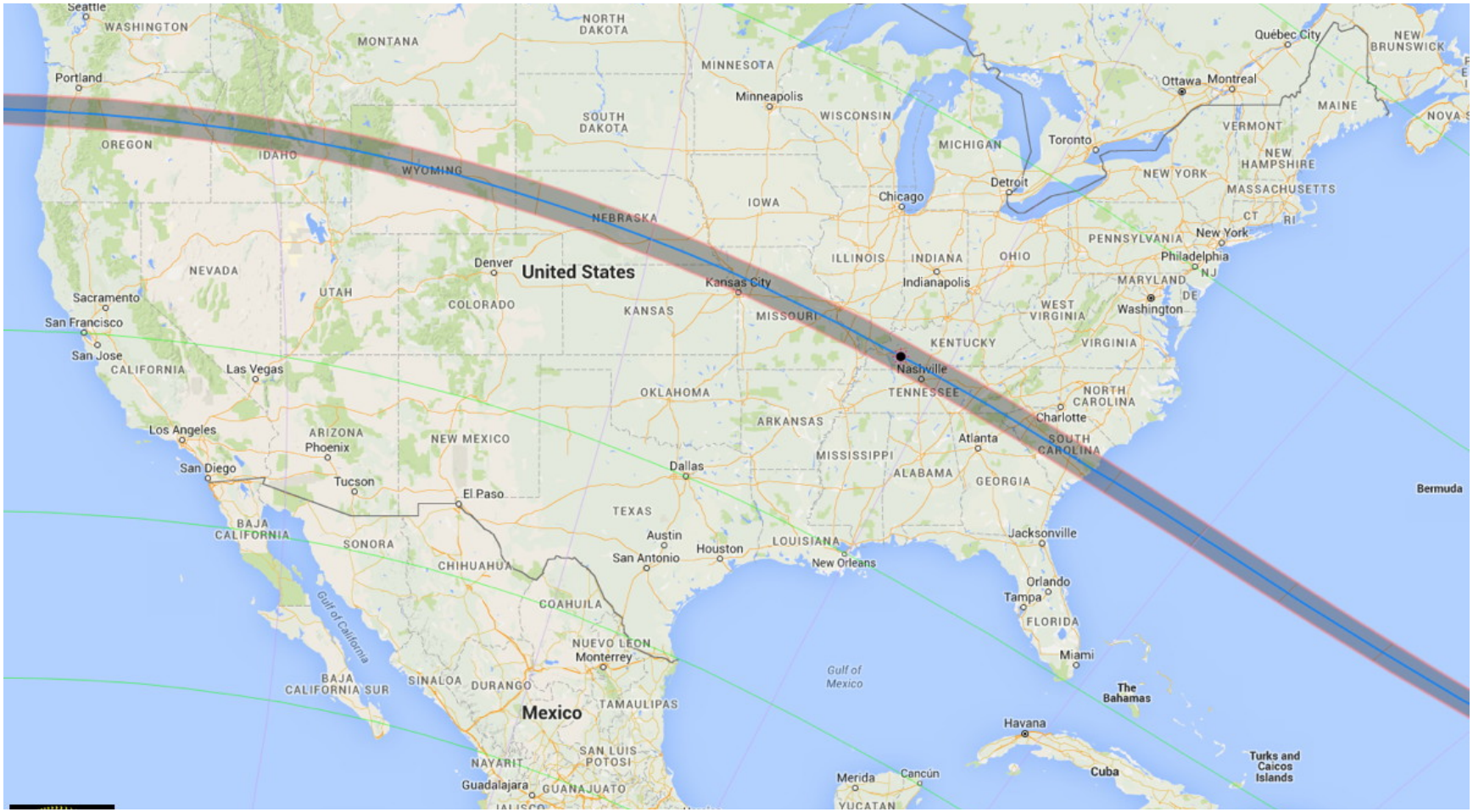
- First contact was made on 20 August 2016
- Declared spacecraft emergency and had repeated contacts over the next two weeks
  - Ascertain Spacecraft status
  - Disable autonomy
  - Charge Battery – Partially damaged (2 cells) – max volts ~26V
  - Warm up propulsion system
- Attempted autonomous recovery on 7 September 2016
  - Propulsion system warm – no pressure however
  - Battery charged sufficiently
  - Bad gyro's masked
  - Results
    - Spacecraft reset, autonomy rules fired, ST locked, momentum dump attempted
    - Momentum decreased some but not as much as expected – 2 wheels saturated
    - Did not regain attitude control or end up continuously power positive.
    - Intermittent contact; Attempts will continue to mitigate further spacecraft degradation



Current orientation supports some solar array input, RF communications only supports uplink of short commands to an LGA. The battery charge rate is C/10 and voltage controller to 12. Power switching boards are on, nearly all switched loads off. The TWTA is in standby, IEM (avionics), PDU 1553 bus, and propulsion tank primary heaters are on. EA mode is enabled.

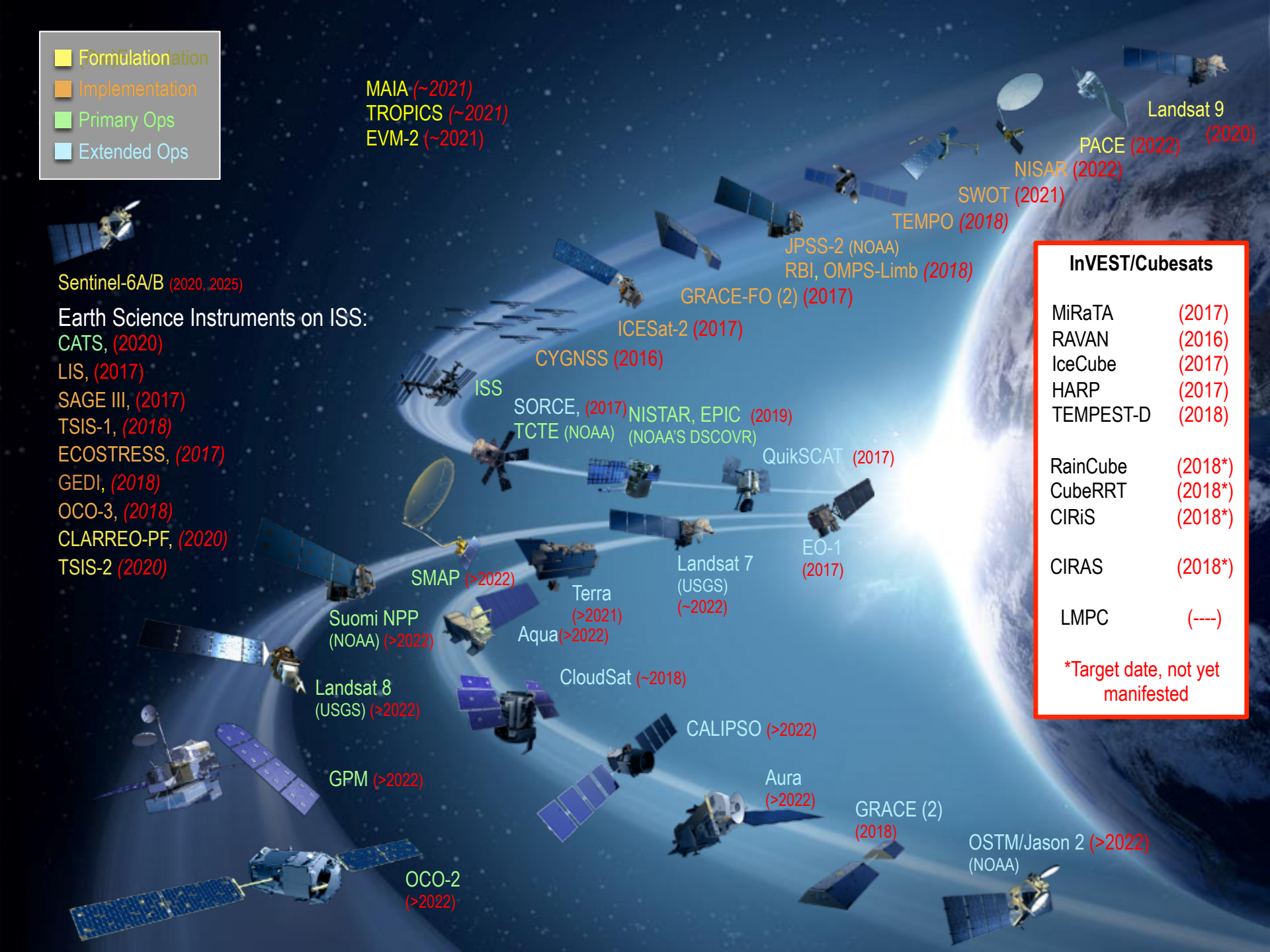
Recovery attempts continued until mid-October when BEHIND moved into an unfavorable alignment on getting sunlight onto the solar panels. It is anticipated that we will continue monthly contacts until June 2017. At that point we will suspend attempts until the summer of 2020, when the alignment becomes more favorable.

Solar Eclipse Path of Totality, 21 August 2017



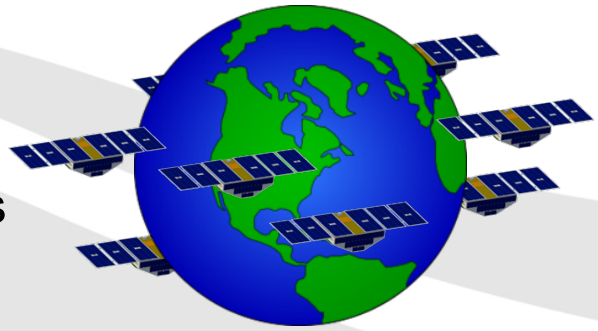
Total Solar Eclipse 2017
NASA Research Announcement (NRA)

- NASA Research Announcement (NRA) for the total solar eclipse in August 2017 released on 28 September
- Primary purpose of NRA is to support development of new research or enhancement of existing research applied to the 2017 eclipse
- Building on existing partnerships and the use of interdisciplinary or citizen science approaches is encouraged
- Proposals must demonstrate links to the 2017 solar eclipse
- Two-step proposal process
  - Step-1 proposals due 27 October
  - Step-2 proposals due 30 November
- Total award value is approximately $0.8M (Heliophysics); ***may*** be supplemented by other SMD Divisions if applicable proposals are received and panel recommends award

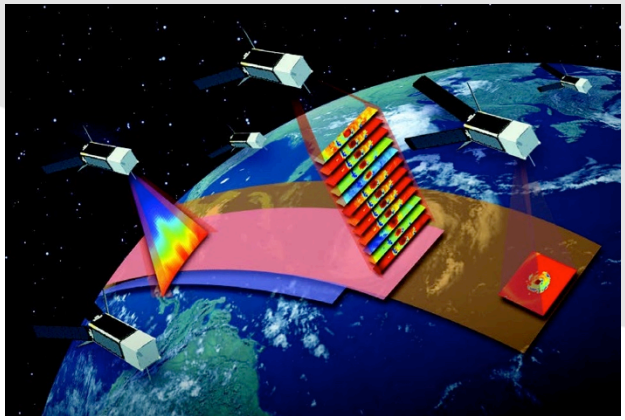

Formulation
Implementation
Primary Ops
Extended Ops
MAIA (~2021)
TROPICS (~2021)
EVM-2 (~2021)
Landsat 9 (2020)
PACE (2022)
NISAR (2022)
SWOT (2021)
TEMPO (2018)
JPSS-2 (NOAA)
RBI, OMPS-Limb (2018)
GRACE-FO (2) (2017)
ICESat-2 (2017)
CYGNSS (2016)
Sentinel-6A/B (2020, 2025)
Earth Science Instruments on ISS:
CATS, (2020)
LIS, (2017)
SAGE III, (2017)
TSIS-1, (2018)
ECOSTRESS, (2017)
GEDI, (2018)
OCO-3, (2018)
CLARREO-PF, (2020)
TSIS-2 (2020)
ISS
SORCE, (2017)
TCTE (NOAA)
NISTAR, EPIC (2019)
(NOAA'S DSCOVR)
QuikSCAT (2017)
EO-1 (2017)
Landsat 7 (USGS) (~2022)
SMAP (>2022)
Terra (>2021)
Aqua (>2022)
Suomi NPP (NOAA) (>2022)
CloudSat (~2018)
Landsat 8 (USGS) (>2022)
CALIPSO (>2022)
GPM (>2022)
Aura (>2022)
GRACE (2) (2018)
OSTM/Jason 2 (>2022) (NOAA)
OCO-2 (>2022)
InVEST/Cubesats
MiRaTA (2017)
RAVAN (2016)
IceCube (2017)
HARP (2017)
TEMPEST-D (2018)
RainCube (2018*)
CubeRRT (2018*)
CIRiS (2018*)
CIRAS (2018*)
LMPC (----)
*Target date, not yet manifested

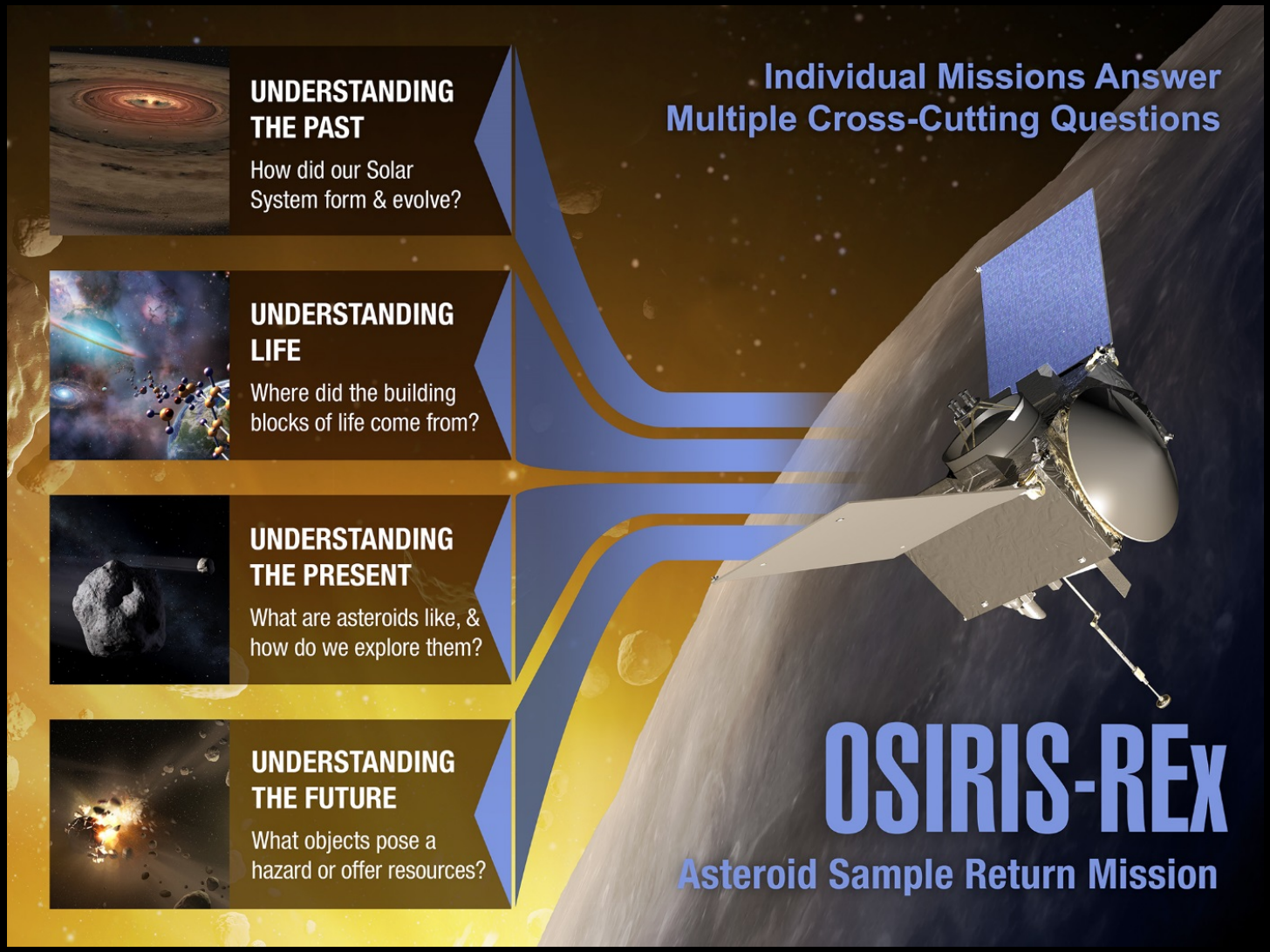
Small Satellite CONSTELLATIONS

- Cyclone Global Navigation Satellite System (CYGNSS)
  - Selected under Earth Venture Mission-1 AO
  - 8-satellite Microsat Constellation to measure winds and air-sea interactions in tropical storms, using reflected GPS
  - Ready for launch scheduled for 12 Dec 2016
  - PI-led (C. Ruf, U. Michigan, plus SWRI)



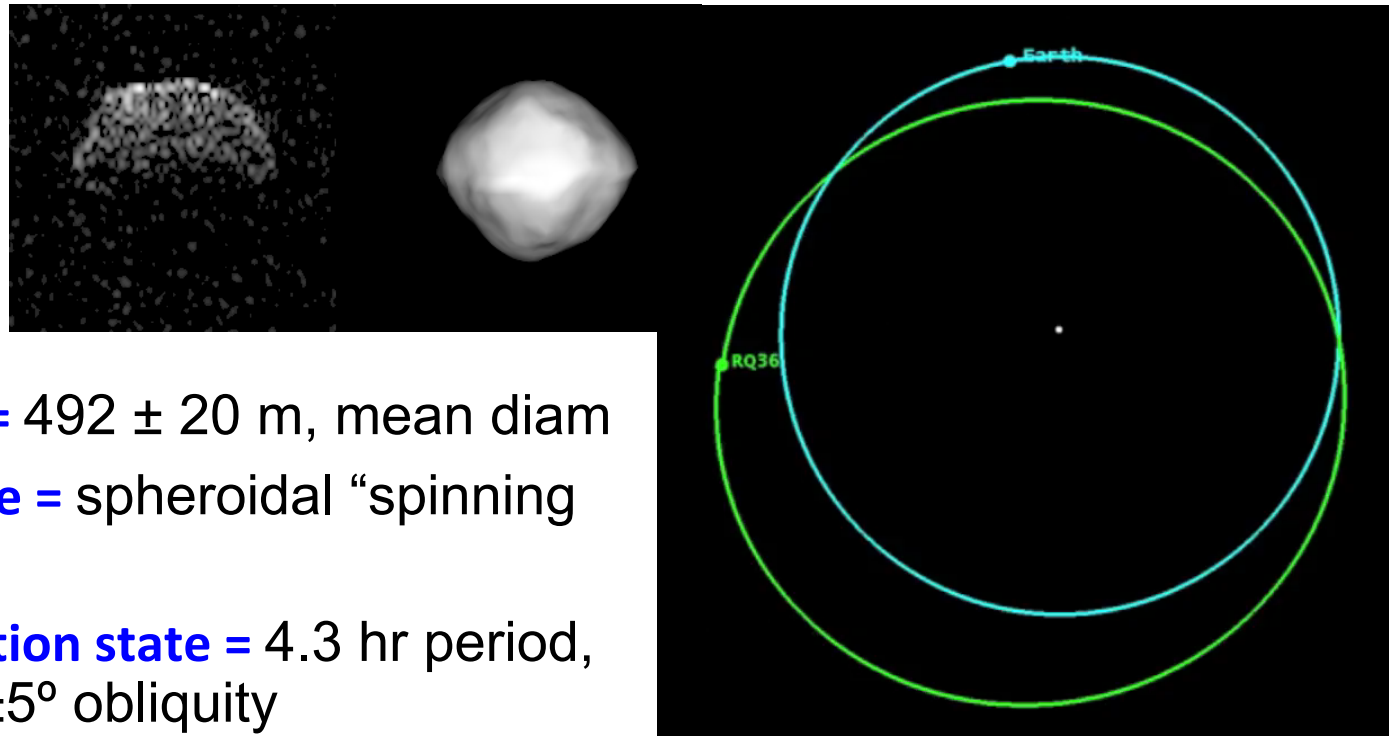
- Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS)
  - Selected under Earth Venture Instrument-3 AO
  - 12-satellite Cubesat Constellation
  - First ***science-focused*** cubesat constellation
  - Targeted for launch in 2020, may use VCLS vehicle
  - PI-led (W. Blackwell, MIT, plus Lincoln Labs and WFF)




UNDERSTANDING THE PAST
How did our Solar System form & evolve?
UNDERSTANDING LIFE
Where did the building blocks of life come from?
UNDERSTANDING THE PRESENT
What are asteroids like, & how do we explore them?
UNDERSTANDING THE FUTURE
What objects pose a hazard or offer resources?
Individual Missions Answer Multiple Cross-Cutting Questions
OSIRIS-REx
Asteroid Sample Return Mission

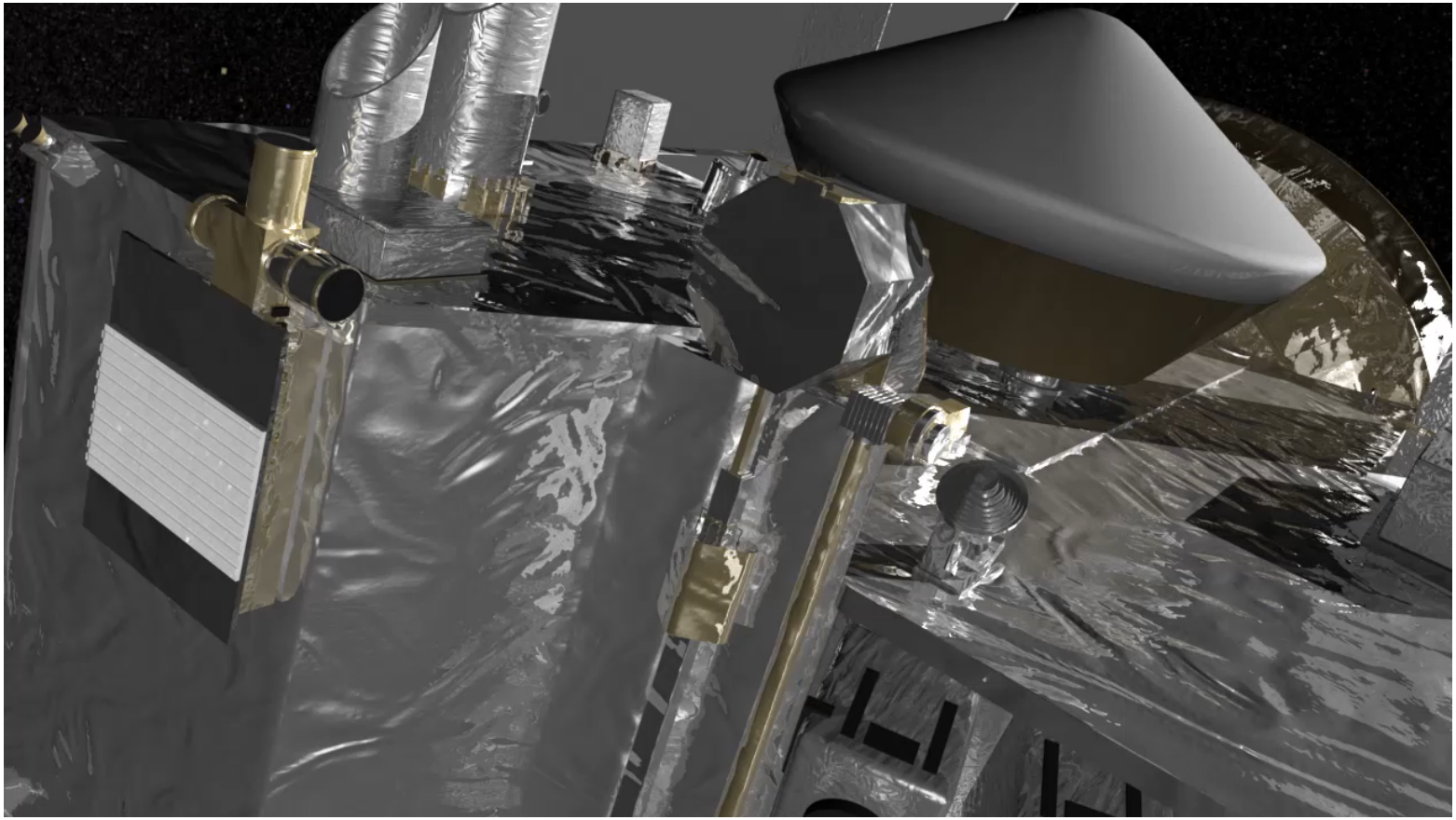
LAUNCH – JUST EXACTLY PERFECT

About Bennu



- **Size =** 492 ± 20 m, mean diam
- **Shape =** spheroidal “spinning top”
- **Rotation state =** 4.3 hr period, 180±5º obliquity
- **Spectral Class**: B-type Apollo (Earth-crossing) asteroid

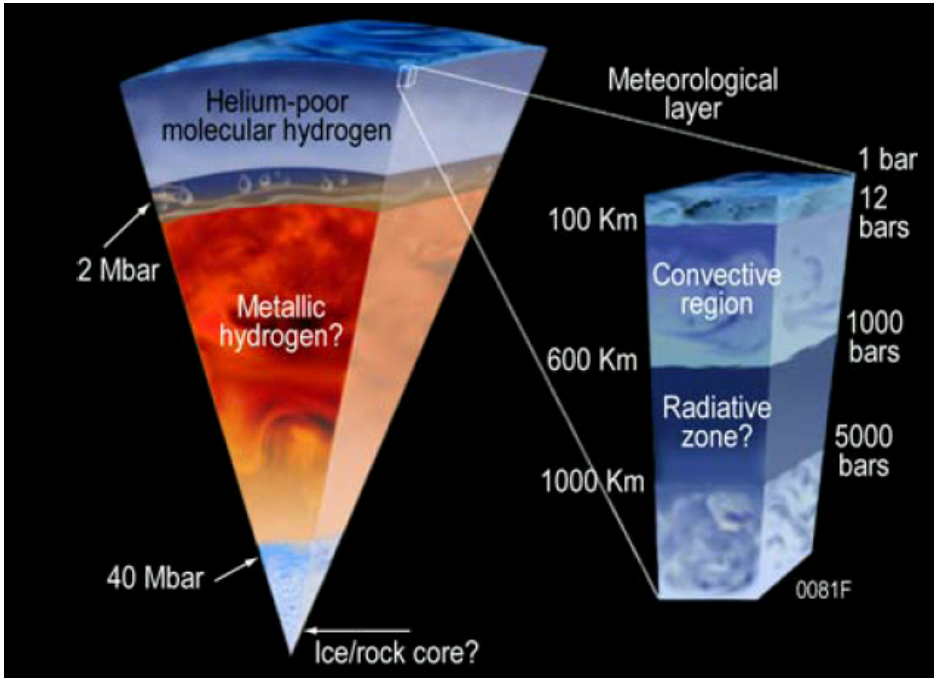
Touch-and-Go Sample Maneuver (TAG)

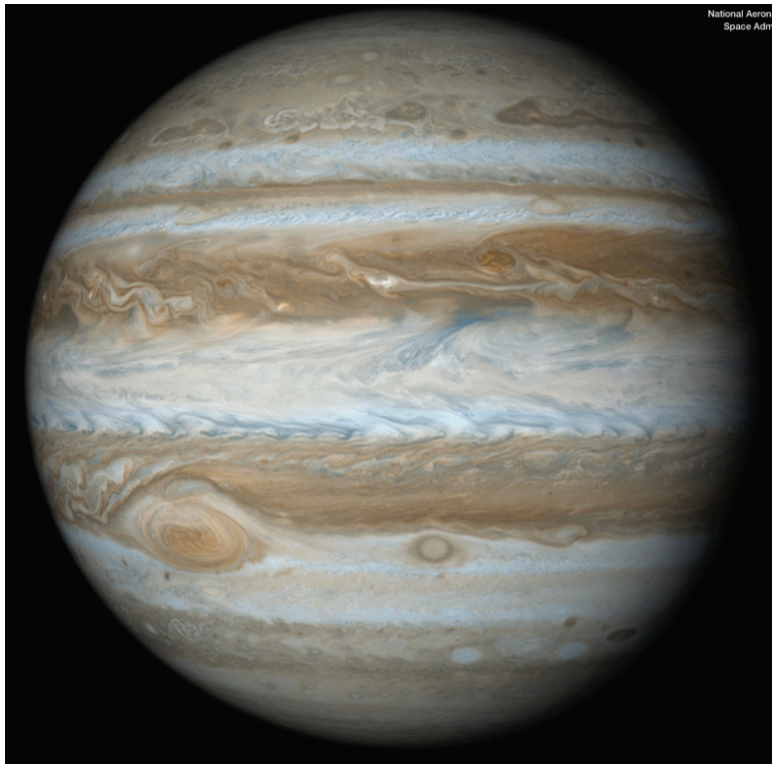


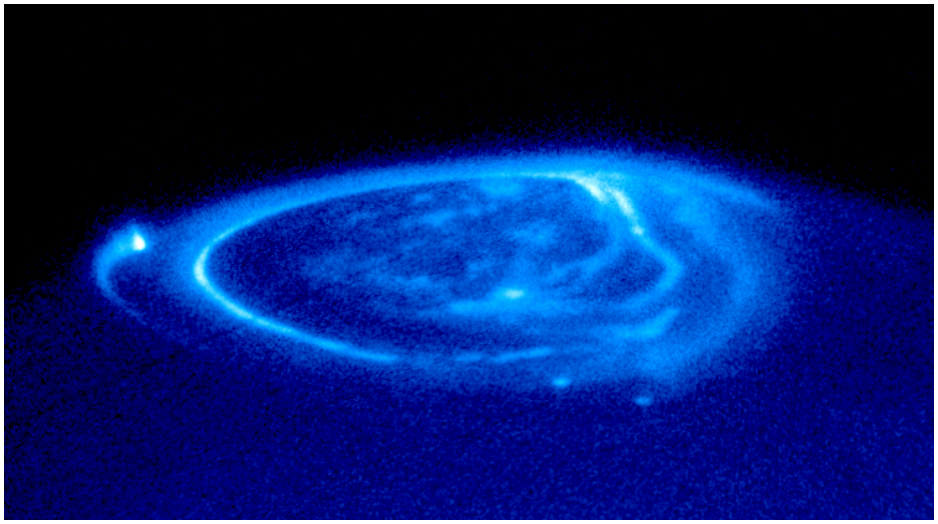
Juno: Mission to the Planet Jupiter

Science Objectives:

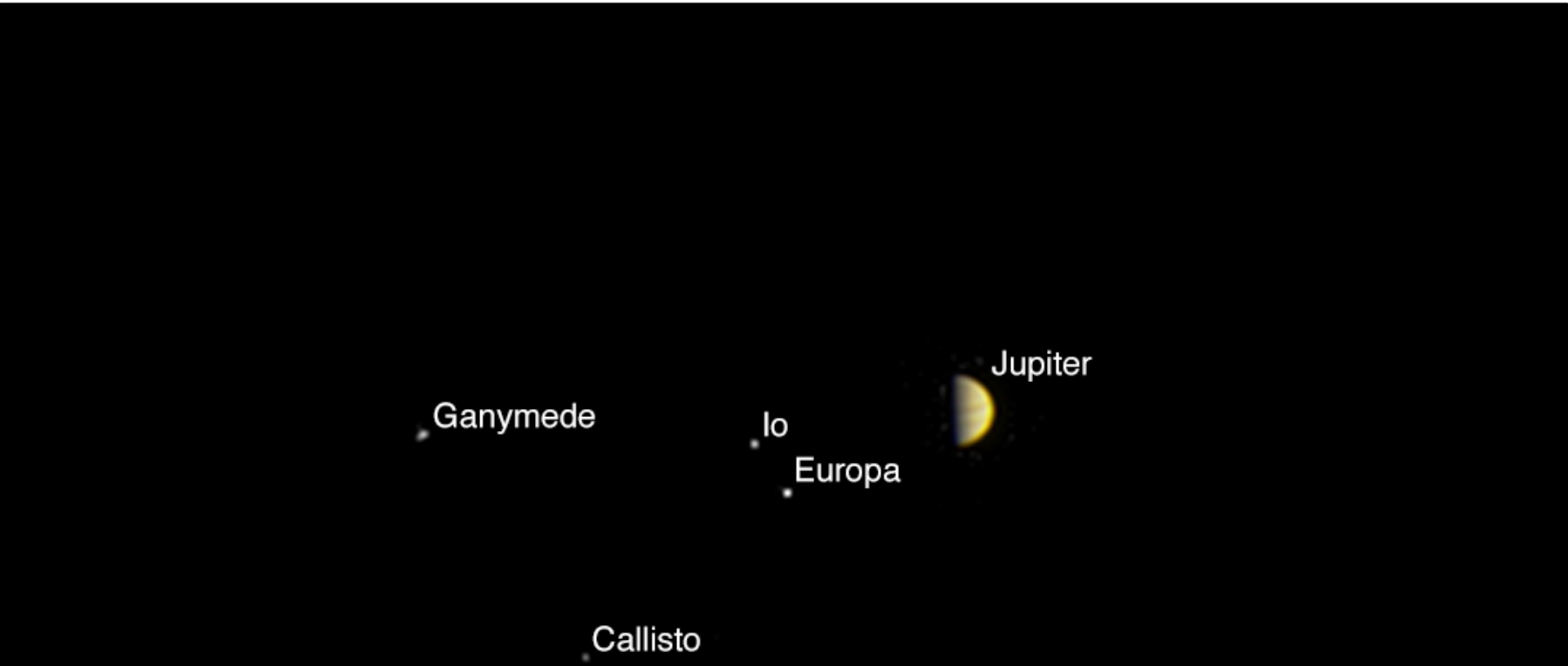
- Origin
- Interior Structure
- Atmosphere Composition & Dynamics
- Polar Magnetosphere







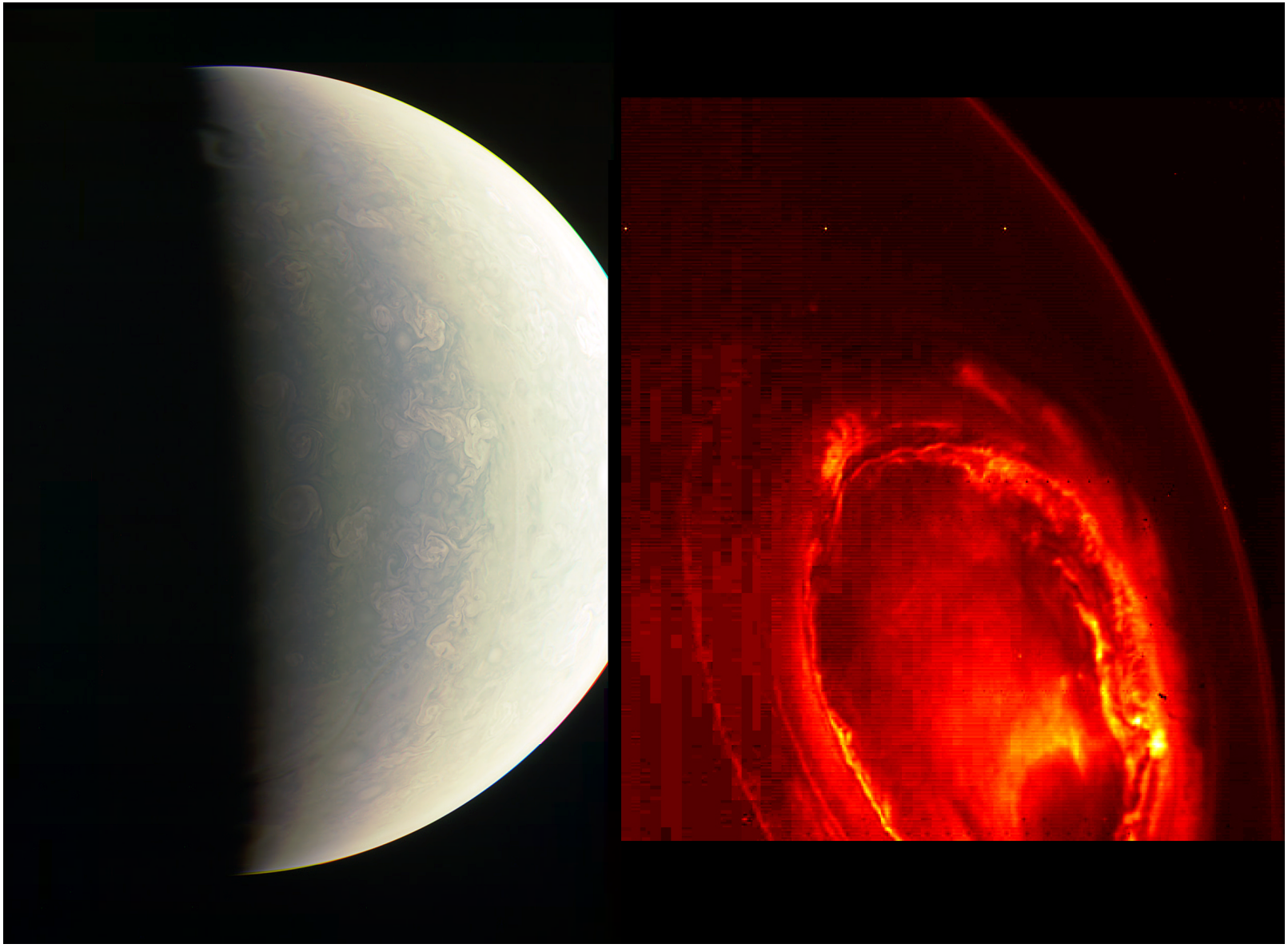
NASA's Juno Spacecraft Closing in on



JunoCam, imaged Jupiter on June 21, 2016, at a distance of 6.8 million miles (10.9 million kilometers) from the gas giant.

First Image Released After JOI

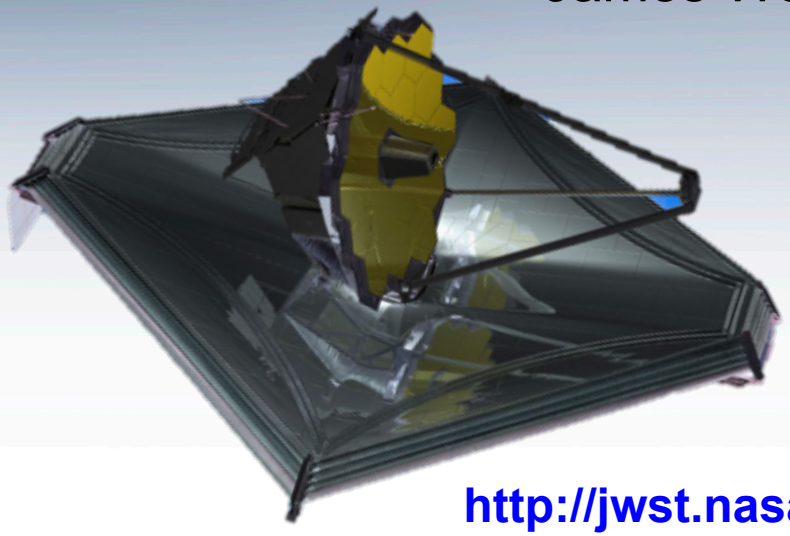
First Orbit: Sample of the Juno Data



Next New Frontiers Program AO

- New Frontiers Program Community Announcements issued January 2016 and April 24, 2016
- Investigations are focused on the following mission themes (listed without priority):
  - Comet Surface Sample Return
  - Enceladus
  - Lunar South Pole-Aitken Basin Sample Return
  - Saturn Probe
  - Titan
  - Trojan Tour and Rendezvous
  - Venus In Situ Explorer
- Draft AO released August 8, 2016

Webb
James Webb Space Telescope



http://jwst.nasa.gov/

Large Infrared Space Observatory

Top priority of 2000 Decadal Survey

Science themes: First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

Mission: 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

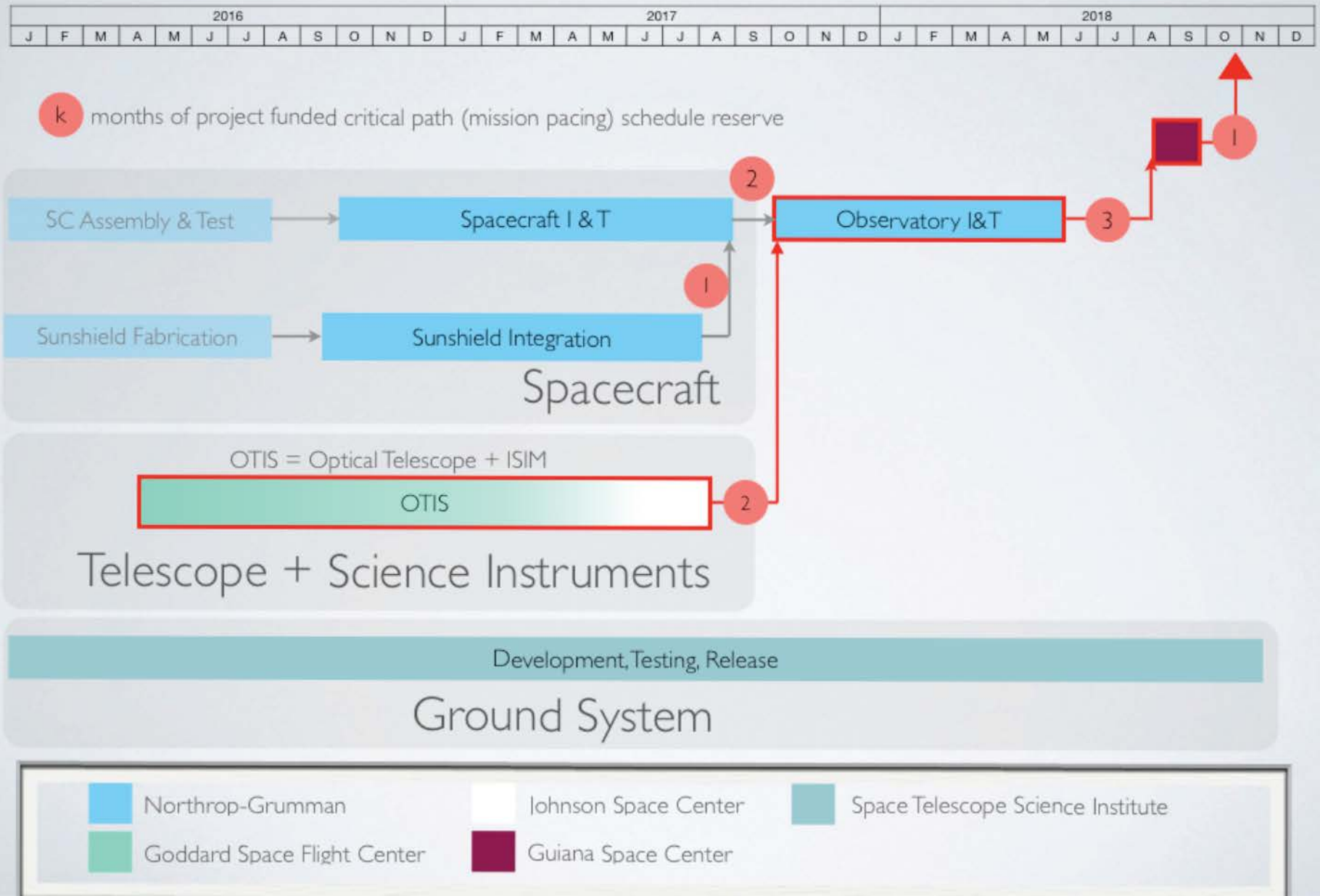
Instruments: Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

Operations: 2018 launch for a 5-year prime mission

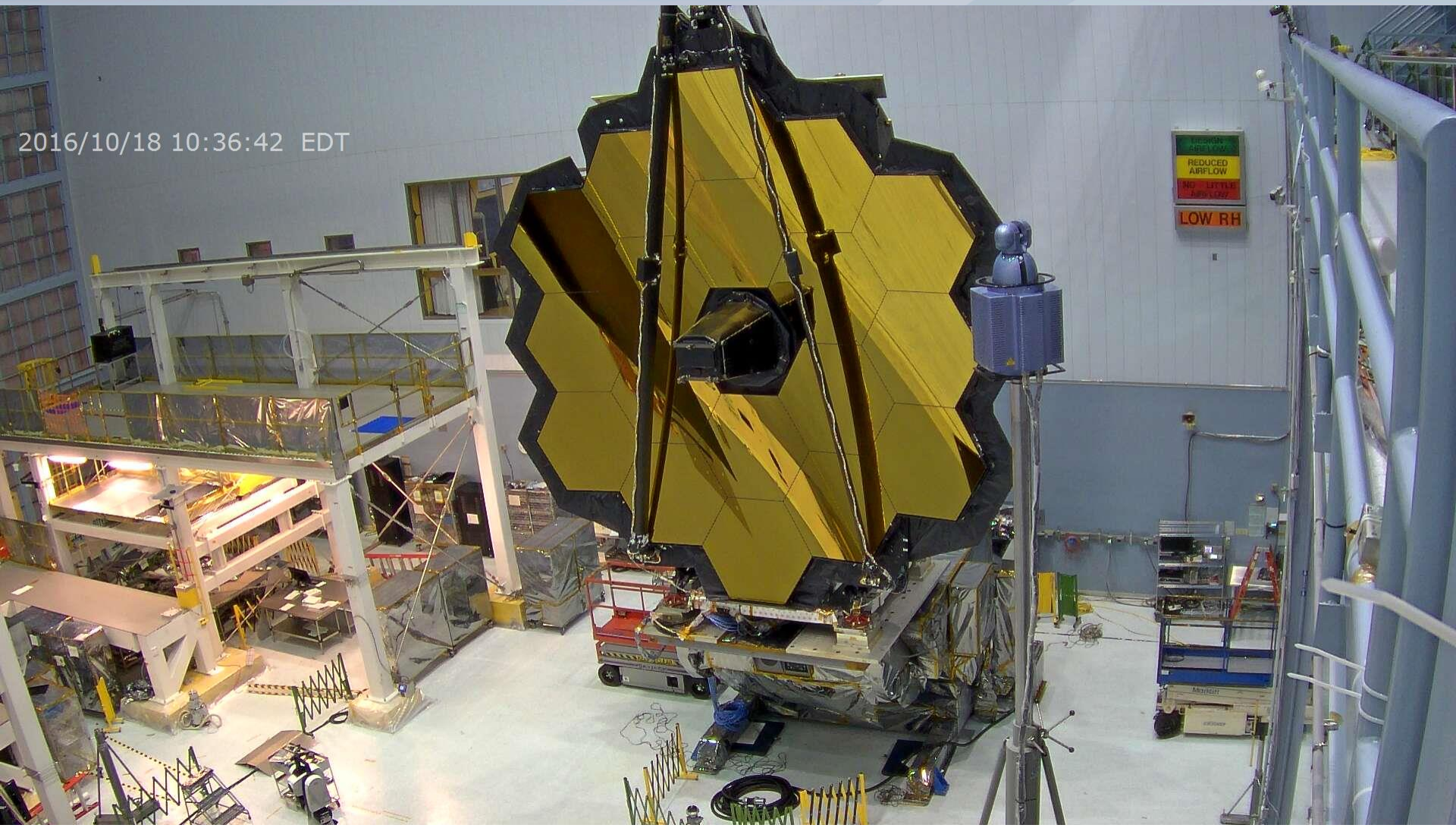
Partners: ESA, CSA

JWST remains on track for an October 2018 launch

SIMPLIFIED SCHEDULE



OTIS (@ GSFC)



OTIS = **O**ptical **T**elescope Element and **I**ntegrated **S**cience Instrument Module

X-ray Recovery Mission (update)

- Hitomi (ASTRO-H) was lost on March 26, 2016.
  - On June 8, JAXA released a report on the cause of the mission-ending anomaly.
  - http://global.jaxa.jp/projects/sat/astro_h/topics.html
- JAXA has proposed an X-ray Recovery Mission (XRRM) to recover the science lost with Hitomi.
  - Proposal is part of JFY2017 budget proposal, which requires Government approval as part of the Japanese budget process.
  - JAXA and NASA have had several rounds of talks on (a) whether NASA will participate in XRRM and (b) what changes would be made for XRRM.
- The NASA Advisory Council discussed on July 28, 2016, that NASA participate in XRRM.
  - NASA should rebuild SXS provided problems leading to loss of Hitomi are solved, does not interfere with decadal Survey priorities, and subject to Mid Term Review report findings.
- As discussed at July APS meeting, should NASA participate, then
  - NASA's hardware role on XRRM would be same as on Hitomi.
  - Project would be directed to GSFC to reduce cost, schedule, and technical risk by leveraging off Hitomi experience and heritage.
  - U.S. community participants, beyond XRRM team at GSFC, would be selected anew from an open call.

Preparing for the 2020 Decadal Survey
Large Mission Concepts

NASA has assembled Science and Technology Definition Teams (STDTs) for each of the four large mission candidates to enable Mission Concept Studies as input to the 2020 Decadal Survey.

http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/

* APS member

STDTs

	Community STDT Chairs	Center Study Scientist	Study Lead Center	HQ Program Scientist
Far IR Surveyor asd.gsfc.nasa.gov/firs	Asantha Cooray* Margaret Meixner	David Leisawitz	GSFC	Kartik Sheth
Habitable Exoplanet Imaging Mission www.jpl.nasa.gov/habex	Scott Gaudi* Sara Seager	Bertrand Mennesson	JPL	Martin Still
Large UV/ Optical/IR Surveyor asd.gsfc.nasa.gov/luvoir	Debra Fischer* Bradley Peterson	Aki Roberge	GSFC	Mario Perez
X-ray Surveyor wwwastro.msfc.nasa.gov/xrs	Feryal Ozel* Alexey Vikhlinin	Jessica Gaskin	MSFC	Dan Evans

STEM Activation

NAS Extended Science Missions Report

Subcommittee Reports

Selected Other Reports

Extending Science – NASA's Space Science Mission Extensions and the Senior Review Process
The National Academies

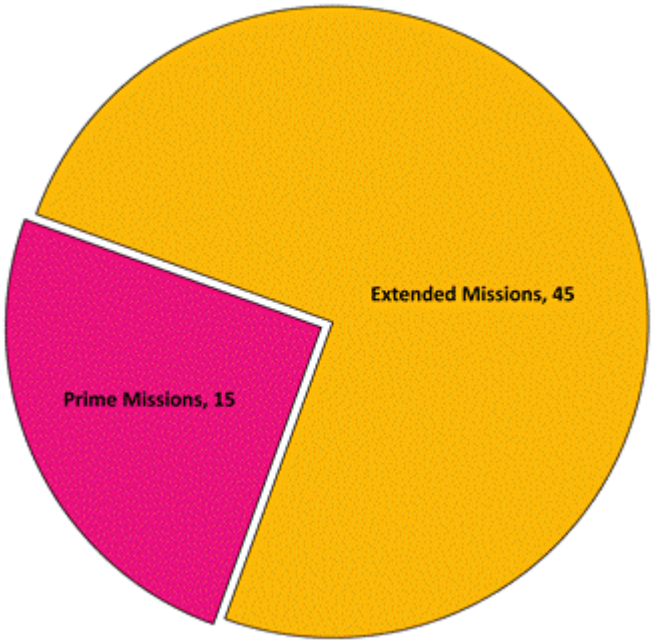
Extended Mission Science is Productive and Valuable

- Voyagers in operation nearly 40 years, over three decades beyond prime missions, now at edge of the heliosphere
- Together with Hubble, the Spitzer Space Telescope identified very distant galaxy GNz-11, finding that star formation proceeds much more rapidly than previously known in early universe
- The Aqua Earth-observing spacecraft showed that the melting of the Greenland ice sheet in 2012 was the most extensive surface melting measured to date
- The STEREO spacecraft obtained the first 360 degree images of the sun
- The Mars Exploration Rovers Spirit and Opportunity identified habitable hydrothermal environments on Mars
- The Lunar Reconnaissance Orbiter identified thin layers of water ice in the permanently shadowed polar regions

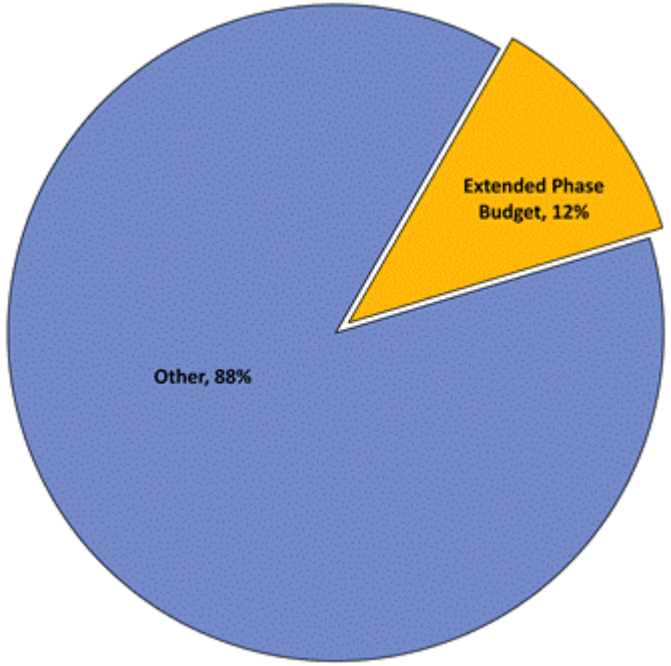
Extended Mission Science is a Bargain

Approximately three quarters of the NASA science missions currently flying are in extended phase, but represent only ~12% of the Science Mission Directorate's FY16 budget

Active space science missions



SMD budget, including extended phase missions



Bottom Line:

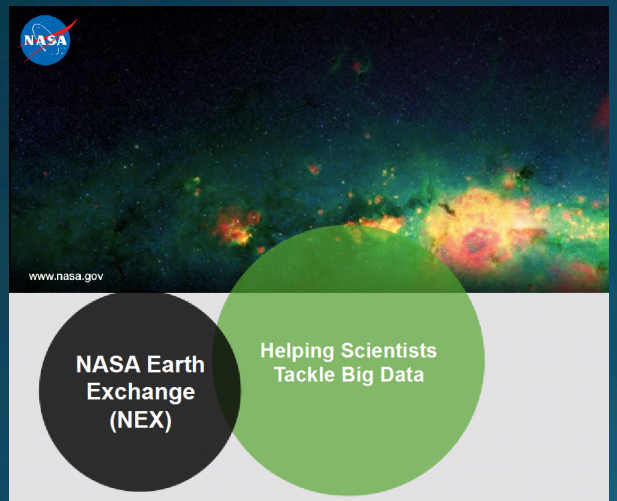
- **Many extended science missions have made important discoveries via new destinations, observation types or targets, and/or data analysis methods**
- **Continuous coverage, long-baseline data sets, and statistically significant observations of infrequent events require continuity of measurement over years or decades and are best provided through missions in extended phase**
- **NASA's extended missions commonly achieve science objectives identified by the decadal surveys while providing unique insights for determining priorities and approaches for future exploration**

Based upon its assessment, the committee concluded that extended phase science missions are a vital part of NASA's overall science effort.

Big Data Task Force

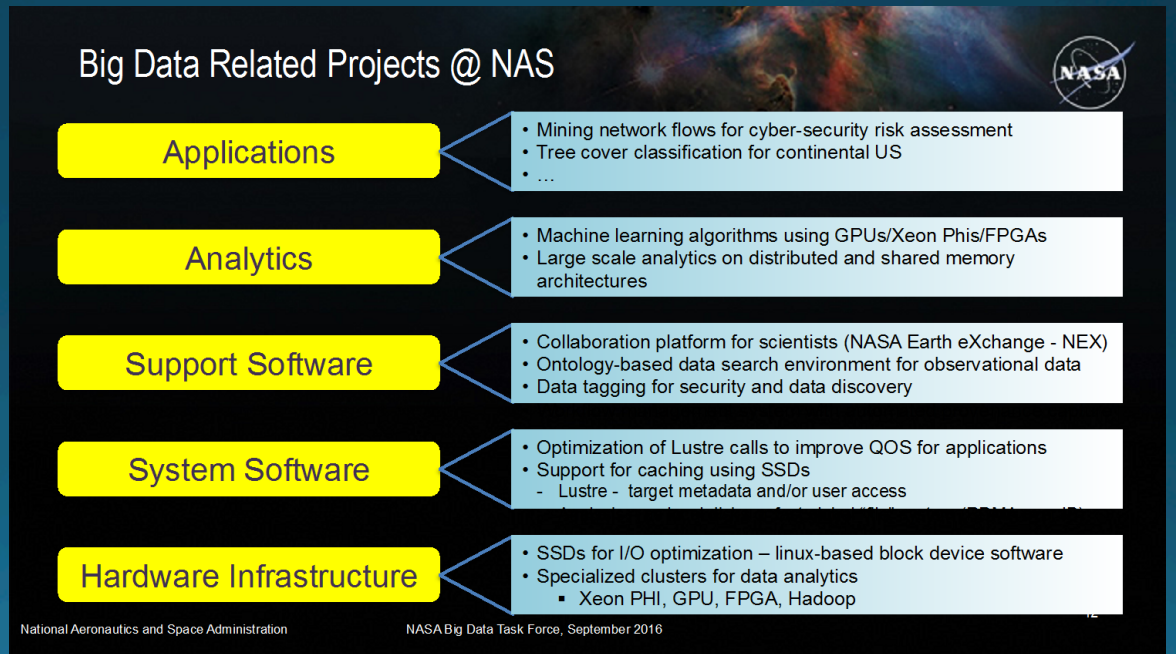
The BDTF has been surveying NASA's entire big data capability with in-depth and cutting-edge sessions during its three meetings at NASA HQ (telecon), Goddard Space Flight Center, and Ames Research Center, including presentations from and discussions with outside collaborators (e.g. NSF, Caltech, Moore Foundation).

3rd Meeting of the BDTF - Ames Research Center, Sept. 28-30, 2016



+ NEX is virtual collaborative that brings scientists together in a knowledge-based social network and provides the necessary tools, computing power, and access to bigdata to accelerate research, innovation and provide transparency.

NASA Advanced Supercomputing (NAS) Division at Ames



Big Data Task Force

The BDTF Terms of Reference is being revised to continue the task force until January 2018, at which time it will provide its final reports.

BDTF Workplan

1. Survey and nominate topics for study. - *Done*
2. Choose 3 to **4** topics. - *Done.*
3. Define problem and approach to each study. - *Done.*
4. Produce products:
   - Research, - Starting
   - Organize and develop positions,
   - Form consensus, and
   - Draft and present results from each study in the form of a white paper with accompanying slide presentation.

Status of NASA's High End Computing Capabilities

- SMD manages two supercomputing centers: (1) High-End Computing Capability (HECC) at Ames Research Center and (2) NASA Center for Climate Simulations (NCCS) at Goddard Space Flight Center.
- HECC is an Agency asset managed by SMD and supports all the Mission Directorates. Roughly 52% of the HECC resource is allocated to SMD. Additional 5% of the peak capacity held as "Agency Reserve" is currently allocated to Astrophysics. In FY17, this represents a total of 142M SBUs.
- HECC is tasked to maintain a stable core high-end computing capability (facility, technology, and human capital) to provide baseline computational resources, protect a core agency capability from program content fluctuations and to allow missions to invest in (on an as needed and just-in-time basis) additional capability at marginal cost.
- NCCS is an Earth Science invested computing center. In FY17, it will provide $106M SBUs.
- Status in 2016:
  - The rise in HECC needs continues and is accelerating in all disciplines.
  - NASA has maxed-out the current supercomputing facilities. There is no capacity to address the ever increasing programmatic requirements – even if additional programmatic funding is provided. In September 2016, NASA approved a facility expansion project to address this facility issue.

Mission Support Council Approves HECC Facility Expansion Project

- HECC is mandated to provide the consolidated high-end computing core capability to the agency, however, the rise in HECC requirements continues and is accelerating with year-to-year growth of HECC utilization exceeding 50% since first being established in 2006.
- To allow continued support to its core mandate, the MSC has approved a facility expansion plan (FY18-FY22) for the design, construction and operation of a new HECC Modular Supercomputing Facility (MSF) at the Ames Research Center.

Artist's rendering of Modular Supercomputing Facility

- The project will accommodate up to 16 modular containerized data units, providing significantly more computing capability than Pleiades, but with the same power usage and dramatically more efficient cooling:
  - 84% and 99.4% in projected power and annual water savings, respectively, for cooling 16 racks for 1 year.
- MSF offers flexibility to modify/react to changing capabilities in High Performance Computing and energy technology faster than a dedicated building.

- MSF will also allow the HECC capability to address new mission directorate programmatic requirements especially to provide prompt solutions to emerging requirements at marginal cost.

SMD Science STEM Activation Restructuring

- Background – FY16 Appropriation provides $37M for NASA Science STEM
- Why Restructure? To further enable NASA science experts and content into the learning environment more effectively and efficiently with learners of all ages. SMD will no longer have minimum of 1 percent set-asides through our missions, or issue disparate 3-year grants. But we are taking a strategic approach, building on our science-disciplined based legacy, and looking for new approaches given Stakeholder priorities
- Objectives?
  - Enable STEM Education
  - Improve US Scientific Literacy
  - Advance National Educational Goals
  - Leverage Through Partnerships
- New name reflects the transition from the planning phase to the doing, or activation, phase of the restructuring

- 27 Awardees posted at: http://www.nasa.gov/press-release/nasa-selects-science-education-partners-for-stem-agreements

Outline

- Science Results
- Programmatic Status
- **Findings**

Old Business

- The Science Committee had a number of findings and recommendations at the July meeting, but the NAC did not formally consider these on account of quorum concerns.

SC Recommendation: Hitomi
(Request Transmission to SMD AA)

Recommendation:

The Science Committee recommends that NASA proceed with the plan to rebuild the Soft X-ray Spectrometer (SXS) instrument, with the appropriate level of emphasis given astrophysics decadal survey priorities.

Major Reasons for the Recommendation:

On March 26th, Hitomi (née Astro-H) experienced an unrecoverable failure. Before the failure, the successful demonstration of the SXS demonstrated Technology Readiness Level (TRL)-9 for this technology and retired the technology maturation risk. On June 1 and June 14, Japan Aerospace Exploration Agency (JAXA) President Okumura announced JAXA's intent to study a rebuild of Hitomi ("ASTRO-H2") and JAXA has asked NASA to consider participating in the mission. NASA has agreed to consider a build-to-print of the instrument demonstrated on Hitomi. JAXA has indicated a desire to begin development of ASTRO-H2, if approved, in FY2017.

SC Recommendation: Hitomi (cont.)

Assuming a build-to-print SXS instrument, and taking into account lessons learned and available flight spare parts, the estimated cost for the United States would be $70-90M (FY2017-FY2021) for a 4.5 year Phase A-D (not including operations and Guest Observer program). At this time, it is not known whether any additional funding would be made available to supplement the planned NASA astrophysics budget to undertake a NASA contribution to ASTRO-H2. The approximately $20M per year required for a NASA contribution to ASTRO-H2 is smaller than the challenges to the planned astrophysics program in recent appropriations that have been accommodated with modest acceptable impact.

Consequences of No Action on the Recommendation:

Loss of a unique capability in x-ray observations for the scientific community. Such observations are identified as a priority in the decadal survey.

SC Finding: Astrophysics Data System Modernization (Request Transmission to SMD AA)

Finding:

The Astrophysics Data System (ADS) is a large bibliographic, web-based system that provides a searchable database of the research literature in astronomy, solar physics, solar-terrestrial interactions, planetary science, earth science and physics. It is funded out of the NASA SMD Astrophysics data archive program that also supports the Science Archive Research Centers. The ADS, freely available to the public, allows a researcher to locate the entire published literature based on queries of author, title, keyword, astronomical target, abstract or full text. Links are provided to references, citations, and on-line data associated with each article. The ADS is widely used and is an invaluable resource to the research community; for instance, it is not uncommon for a space scientist have daily use of the ADS. ADS datasets are up-to-date and the services developed are at the frontier of digital library services. Other scholarly fields often have weaker and more costly bibliographic systems.

Modernization of the ADS database engine, user and visualization interfaces has been proposed but implementation may not be feasible at current funding levels.

SC Finding: Additional Resources Needed in Planetary Protection Office (Request Transmission to SMD AA)

Finding:

The Science Committee finds that additional resources are needed in the NASA Office of Planetary Protection to address increased workload. In recent years, there has been an increase in the number of missions involving planetary protection considerations and in the complexity of those missions. With the growing participation of commercial entities in space exploration, the workload will only increase in the future. Of note, the European Space Agency (ESA) planetary protection office has a larger cadre of staff assigned to the office who provide laboratory capabilities and administrative support. Having additional resources in the NASA Office of Planetary Protection is necessary to ensure ongoing and timely compliance with the Outer Space Treaty. If additional resources are not provided, obligations will not be met in a timely manner, resulting in delays and increased costs.

Observation Regarding Investments in the Modernization of Planetary Protection Technology and Processes

The Science Committee (SC) welcomes NASA's renewed attention to investments in the modernization of planetary protection technology and processes. The SC Planetary Protection Subcommittee notes as well that the European Space Agency (ESA) planetary protection community is currently making similar investments including through the Committee on Space Research (COSPAR) Planetary Protection of Outer Solar System Bodies (PPOSS). The Subcommittee recognizes a significant opportunity for NASA to closely coordinate these new planetary protection technology and process investments with analogous investments within ESA and sponsored by COSPAR. For example, ESA already is investing in the development of a sample capture and flight containment system for a possible Mars sample return cooperation scenario. The involvement of the planetary science community in this process would allow integrated options to be presented.

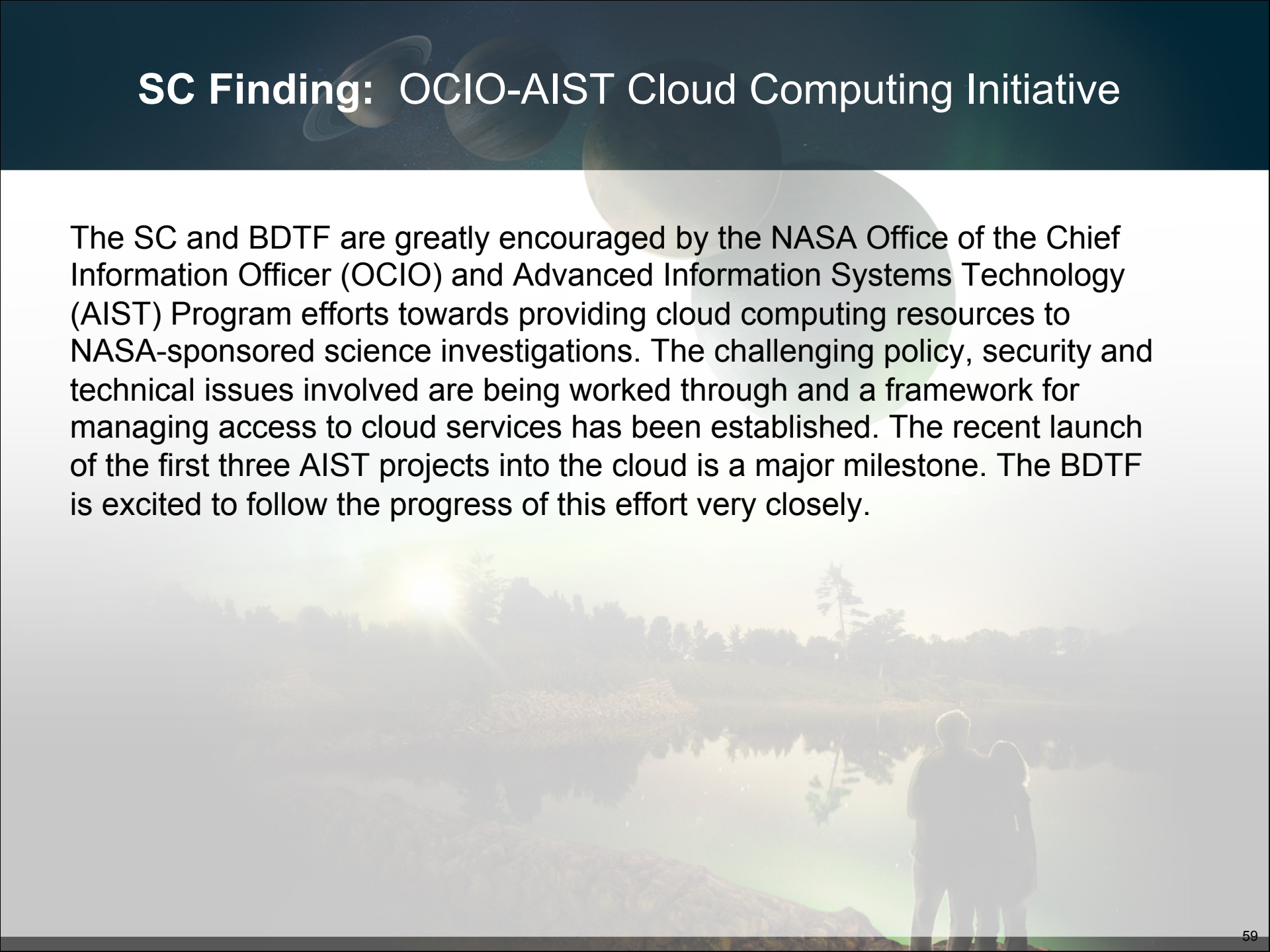
Background: NASA SMD Planetary Science Division (PSD) Director Dr. James Green reported to the Subcommittee that PSD has created a Planetary Protection Technology Definition Team to delineate the planetary protection processes and techniques available to meet future planetary protection mission requirements, and catalog materials and components compatible with planetary protection protocols. The team will report out in November, followed by a Research Opportunities in Space and Earth Sciences (ROSES) call in February 2017 to invest in the necessary technologies.

New Business

- Addition issues from the Science Committee telecon in October.

SC Finding: OCIO-AIST Cloud Computing Initiative

The SC and BDTF are greatly encouraged by the NASA Office of the Chief Information Officer (OCIO) and Advanced Information Systems Technology (AIST) Program efforts towards providing cloud computing resources to NASA-sponsored science investigations. The challenging policy, security and technical issues involved are being worked through and a framework for managing access to cloud services has been established. The recent launch of the first three AIST projects into the cloud is a major milestone. The BDTF is excited to follow the progress of this effort very closely.



SC Finding: Special Regions on Mars Workshop

(for transmission to the SMD AA)

The planetary protection concept of “special regions” on Mars requires a comprehensive science discussion to ascertain the significance of this issue. This potentially has serious consequences for landing site selection, lander and rover operations, and sample return. The SC and PSS suggest that a workshop of experts be co-organized with the PPS to better define naturally occurring special regions and also assess the potential of “induced special regions”

a) through landers or rovers creating a local environment that would be heated and contain aqueous fluids that have sufficiently high water activity and that could persist long enough to plausibly harbor life, and,

b) whether this should prevent further exploration of that site or the return of samples from the vicinity.

Such a workshop could also include Ocean Worlds in order that the planned Europa and other potential missions can be designed with due diligence to planetary protection.

Background: “Induced special regions” might potentially occur through a failed landing or orbit insertion attempt or end-of-life scenario leading to high-velocity impact or the interaction of heat from rovers with RTG power interacting with the surface to induce local melting and high humidity at or just below the surface of Mars, as well as on/within the rover structure. Such conditions could theoretically promote activity of microbes brought from Earth or indigenous to Mars. Understanding the plausibility of this process is critical for developing protocols that would ensure prevention of both forward and backward planetary contamination.

SC Finding: Deep Space Network
(for transmission to the SMD AA)

The SC and the PSS appreciate the summary presentation provided to PSS on the performance and management of the DSN by Space Communications and Navigation (SCaN). However, the SC and PSS are concerned that plans to decommission 34-m stations in Canberra and Goldstone in 2016 and 2017, respectively, will remove an existing redundancy to the aging 70-m stations, which are essential for communication with NASA's most distant assets in the Solar System such as Voyager, New Horizons, and future missions. In particular, New Horizons, now in its extended mission to encounter a Kuiper Belt Object in 2019, has its longest view periods at Canberra. We also remain concerned about the shrinking DSN budget and we urge PSD to resolve this with the SMD Associate Administrator.

Background: As an action item, the PSS has requested that DSN management provide unscheduled station downtime statistics to differentiate between weather and mechanical and other operational issues over the last 5 years. In addition, the PSS has requested SCaN to report their plan for future scheduled station downtime so its impact on flight missions can be assessed. The PSS has requested these data be available by its next meeting in February 2017.

SC Finding: Observing in the Archives
(for transmission to the SMD AA)

The SC and BDTF find that there is an increased scientific use of archival data of NASA missions as measured by the number of published papers. Several archive sites report that over half of new scientific papers are "observing in the archive" rather than relying on solely on new observations, thus doubling the scientific productivity of the missions.

BACKUP

SMD Science STEM Activation Program - Summary

External Evaluator(s) (planned)

Selected through the Office of Education's Blanket Purchase Agreement

National Academy of Science: Board on Science Education

Opportunities

- Enabling of SMD content and experts into additional areas and venues
- Improved coordination across SMD science education
- Reduction in fragmentation and duplication of efforts
- Increased support of targeted audiences based on needs assessments
- Improvement in the understanding of science literacy

Risks/Areas of Concern

- More Dynamic Education environment post ESSA
- Budget uncertainty until restructuring progress is demonstrated. Need $42M/ year to successfully restructure
- Stakeholders disconnecting Science and combining with Education
- Identification of milestones to fill gaps in Formal and Underserved areas

Measurable Achievement

- Progress towards CoSTEM goals by 2020
- Statistical Improvement in applicable S&E Indicators by 2020
- Statistical improvement in scientific literacy surveys by 2020
- Budgets increase reflect progress towards Desired Outcome (Goal is $50M/year by 2020)

Status

- All 27 have been awarded, and Year 1 funding provided
- Kick-off meeting held January 2016 and monthly meetings continue
- "Collective" approach. Over 120 cross-collaboration memorandums signed by PIs
- All 27 awardees have submitted Evaluation Plans to include: descriptions/ plans for audience needs assessments, logic models, reporting and top level metrics
- Meeting of Experts under contract
- Listserve established. "Science WOW!" https://www.nasa.gov/audience/foreducators/Express_Landing.html
- Baseline Review meeting scheduled for week of November 14th
  - Program Reports
  - Set priorities for upcoming year
  - Leveraging efforts
    - Planning calendar for major conferences and events
    - Toolkits
    - 2017 Total Eclipse Planning
- Updates to be posted to http://science.nasa.gov/learners